A night sky with a star trail and a saguaro cactus silhouette. The star trail is a long, curved line of light in the sky, and the saguaro cactus is a dark silhouette in the foreground. The sky is dark with some light clouds.

*"But I am constant as the Northern Star  
Of whose true-fixed and resting quality  
There is no fellow in the firmament."*

*William Shakespeare,*

*Julius Caesar, 3, 1*

# Astronomy C - Variable Stars - 2009

## A. Pulsating Variables:

### 1) Long Period Variables

a) Mira type

b) Semiregular

### 2) Cepheids

### 3) RR Lyrae

## B. Cataclysmic (Eruptive) Variables:

### 1) **Recurrent Novae**

### 2) **T Tauri**

### 3) **Symbiotic**

### 4) **V Geminorum**

### 5) X-Ray Binaries

### 6) Supernovae

a) Type II

b) Type Ia

## C. **Eclipsing Binaries**

# Astronomy C - Variable Stars - 2009

## A. Pulsating Variables:

### 1) Long Period Variables

a) Mira type **Mira, RV Virginis**

b) Semiregular **Betelgeuse**

2) Cepheids **RS Puppis**

3) RR Lyrae

## B. Cataclysmic (Eruptive) Variables:

1) **Recurrent Novae** **RS Ophiuchi**

2) **T Tauri** **T Tauri**

3) **Symbiotic** **Z Andromedae**

4) **V Geminorum** **RX Andromedae**

5) **X-Ray Binaries** **Circinus X-1**

6) **Supernovae**

a) Type II **G292.0+1.8,**

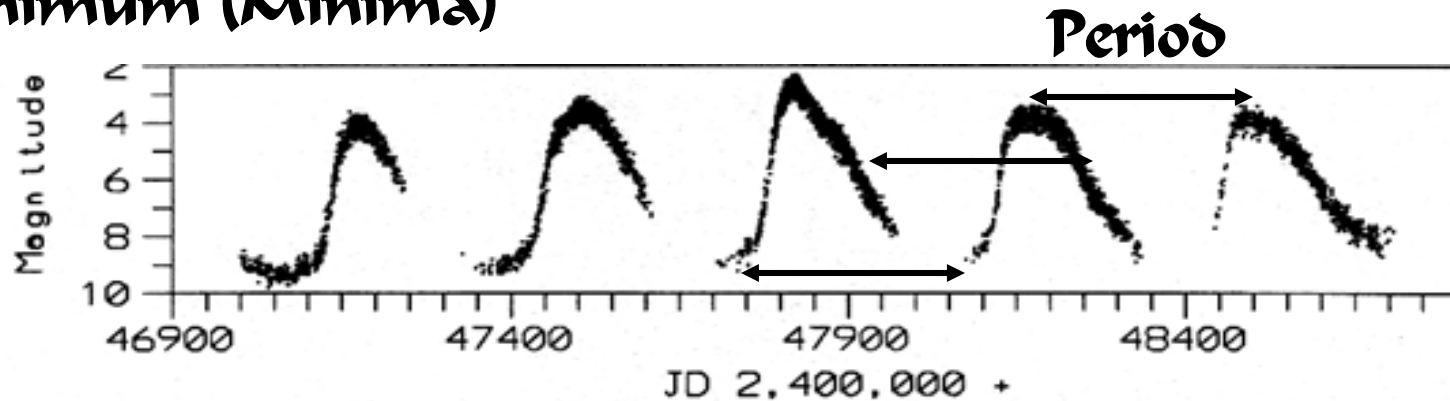
b) Type Ia **SN 1006**

C. **Eclipsing Binaries** **Epsilon Aurigae**

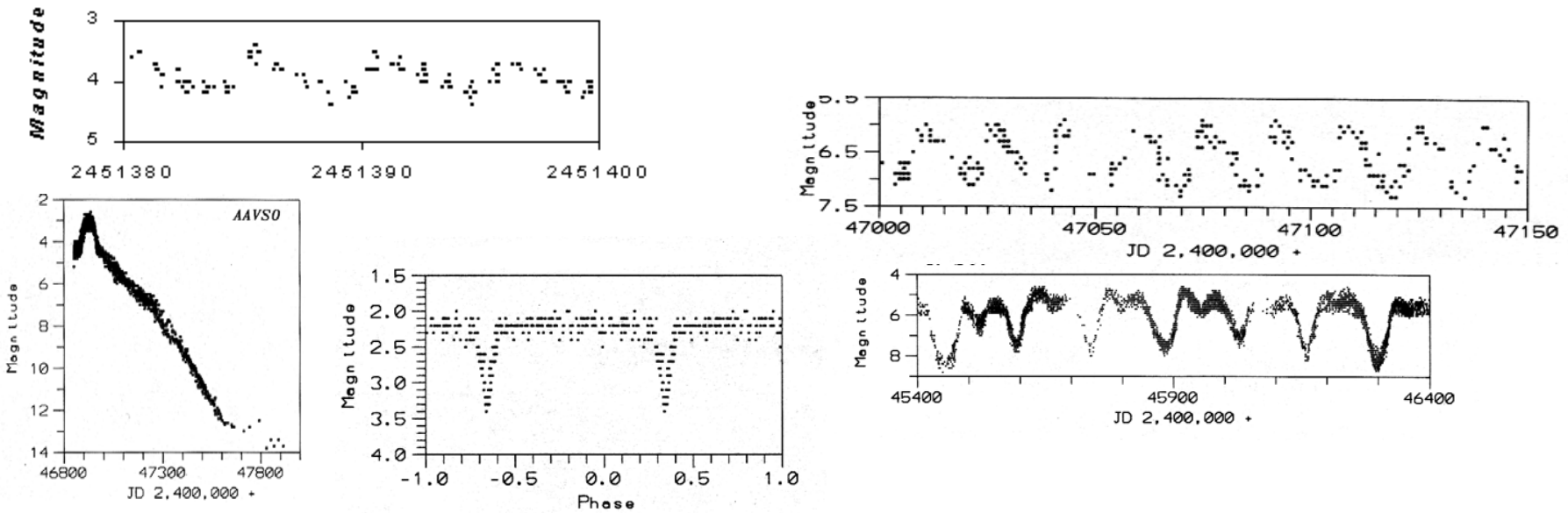
# Light Curves - Variation over Time

Maximum (Maxima)

Minimum (Minima)



## Apparent Magnitude vs Julian Day



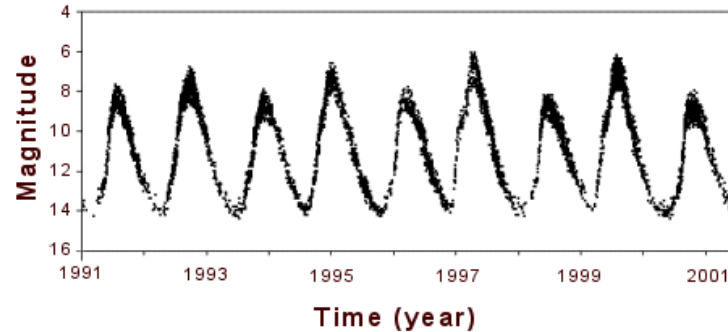
# A. Pulsating Variable Stars:

## 1) Long Period Variables (LPVs)

a) Miras 80 - 1000 days, 2.5 - 5.0 mag

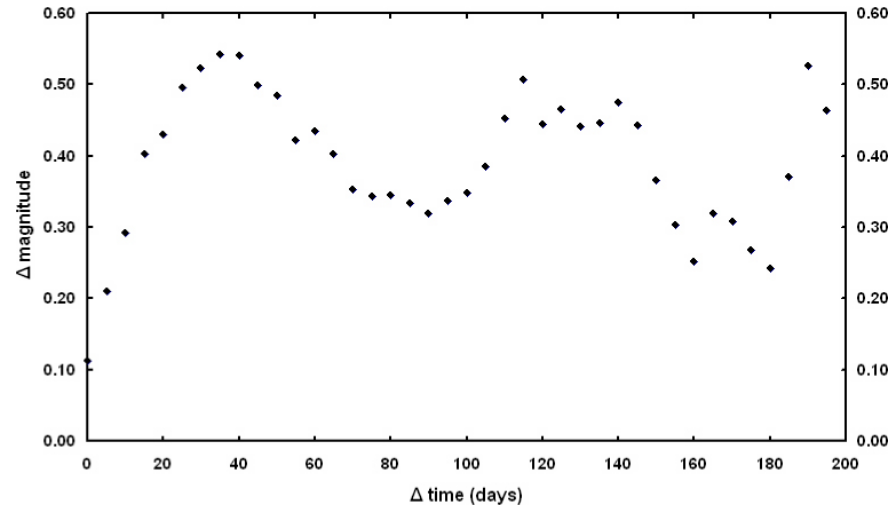
Mira

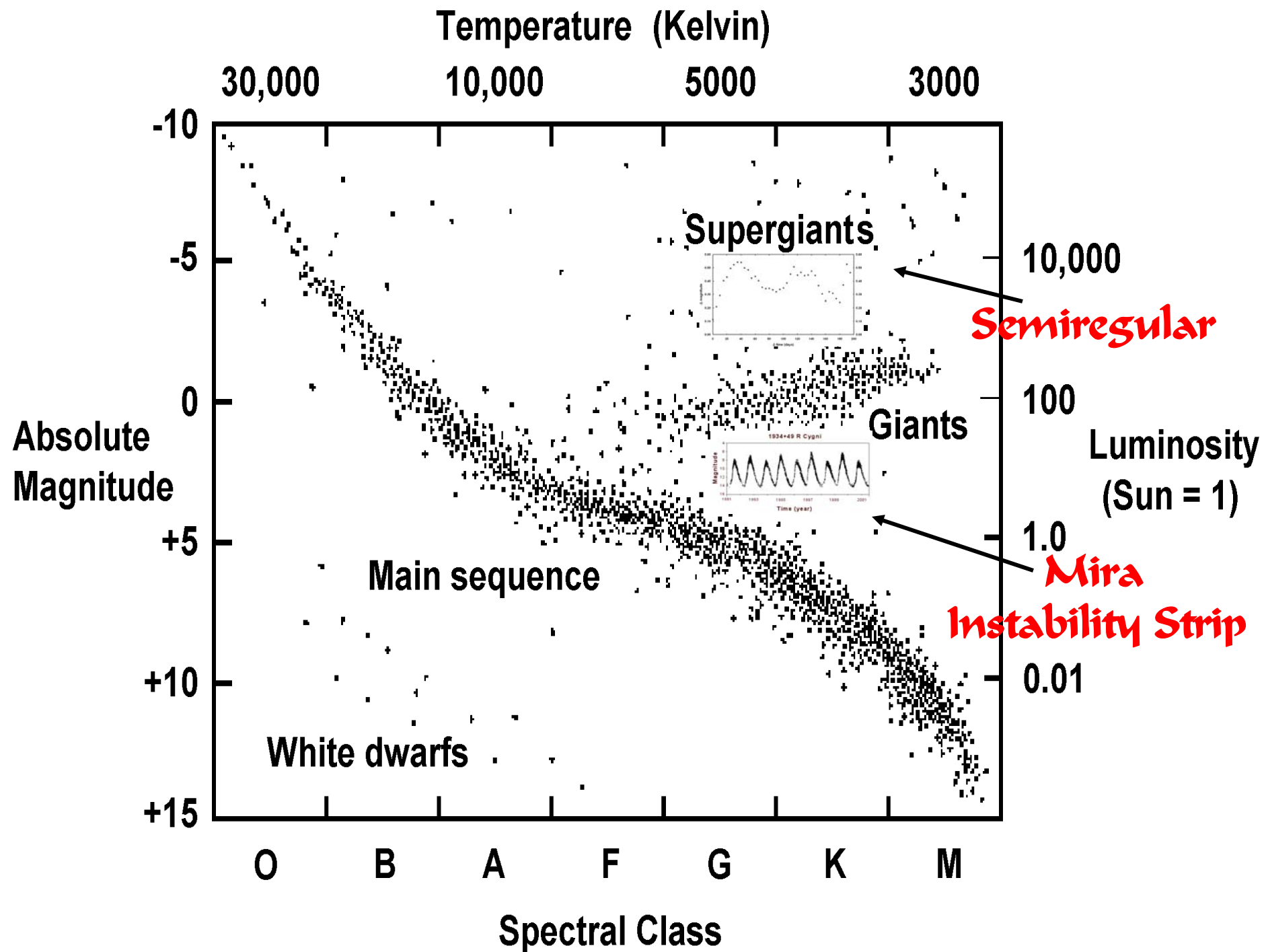
RV Virginis



b) Semiregular Variables 30 - 1000 days, 1.0 - 2.0 mag

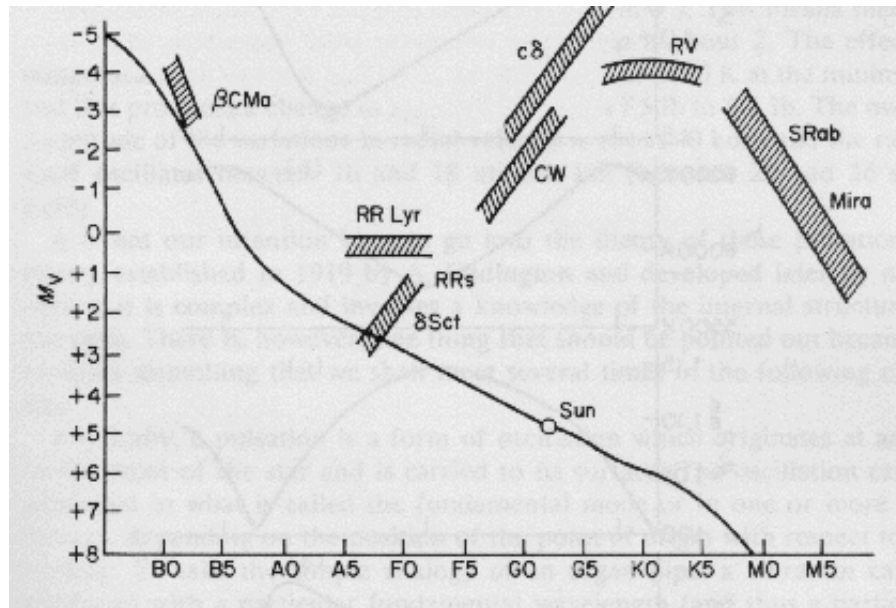
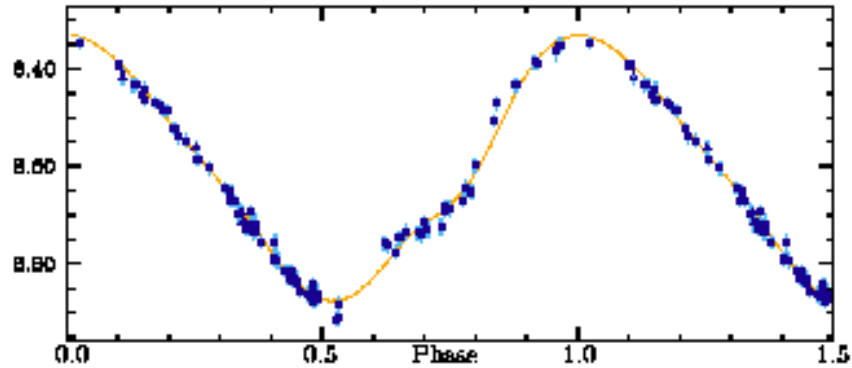
Betelgeuse





# 2) Cepheid Variable Stars

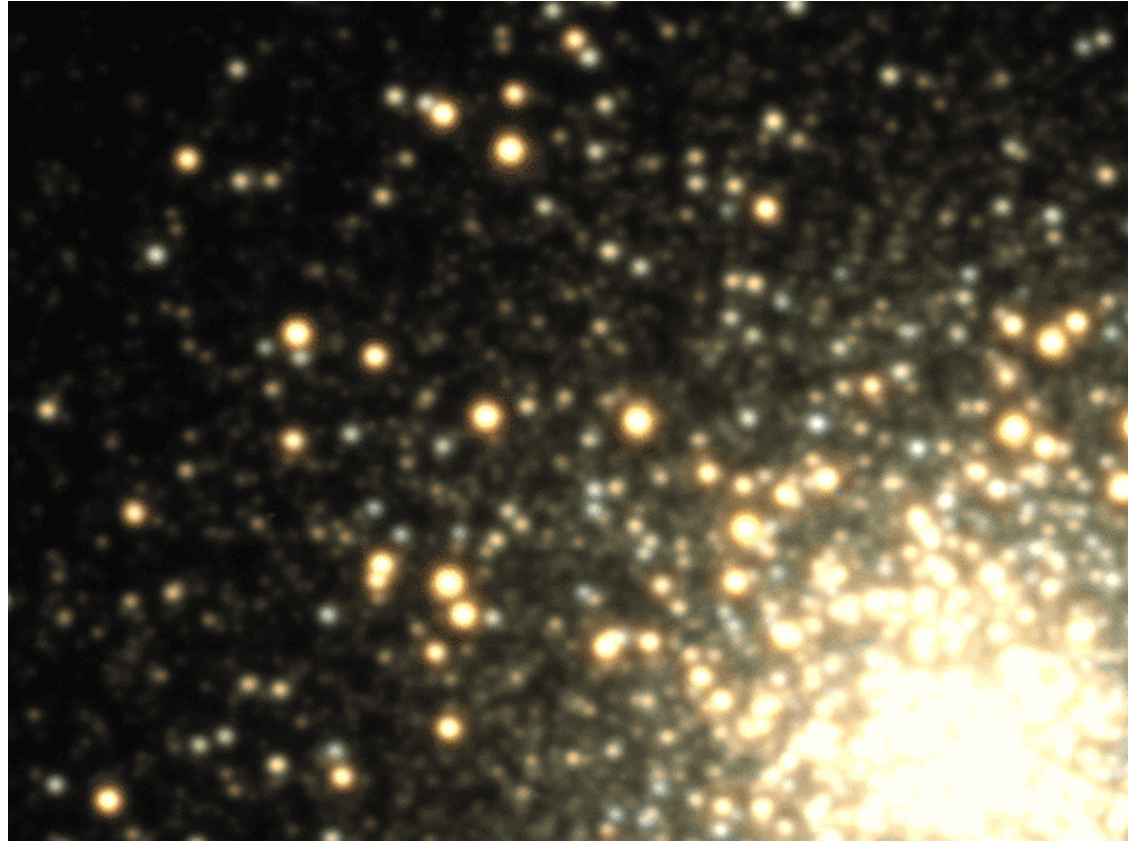
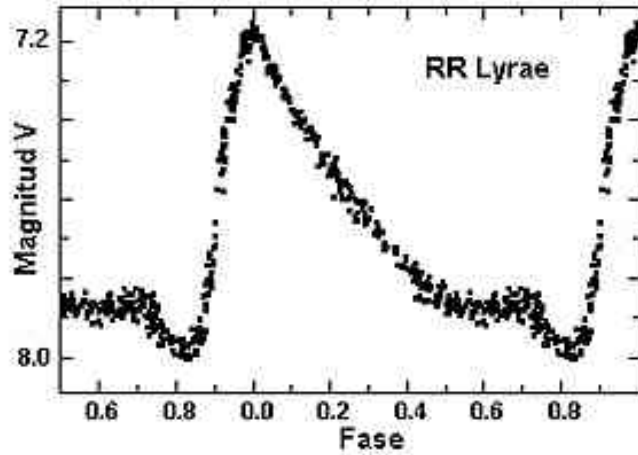
**RS Puppis** [Periods of .8 - 35 days, .3 - 1.2 mag]





# 3) RR Lyrae Variable Stars

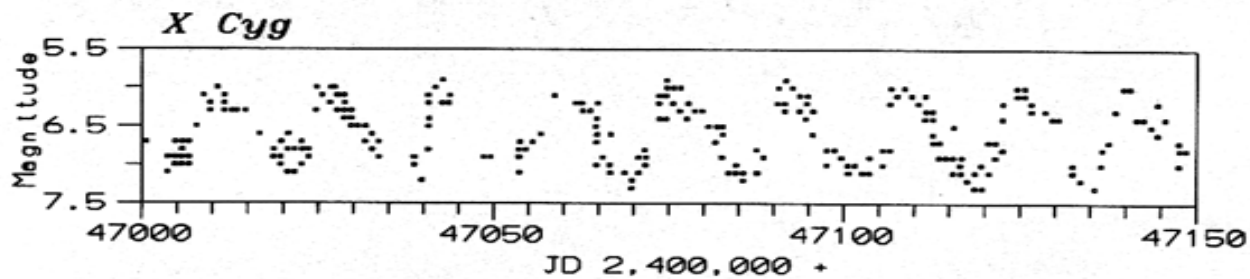
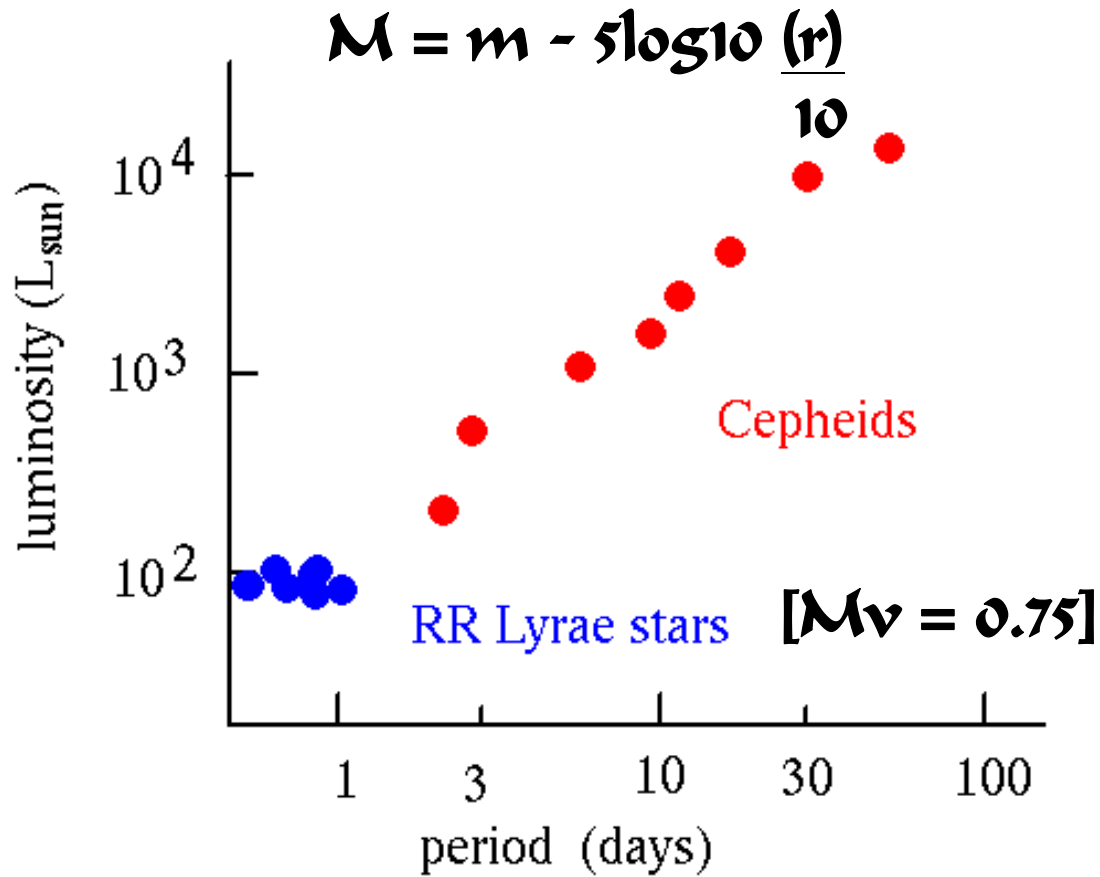
[Periods of .2 - 1 day, .3 - 2.0 mag]

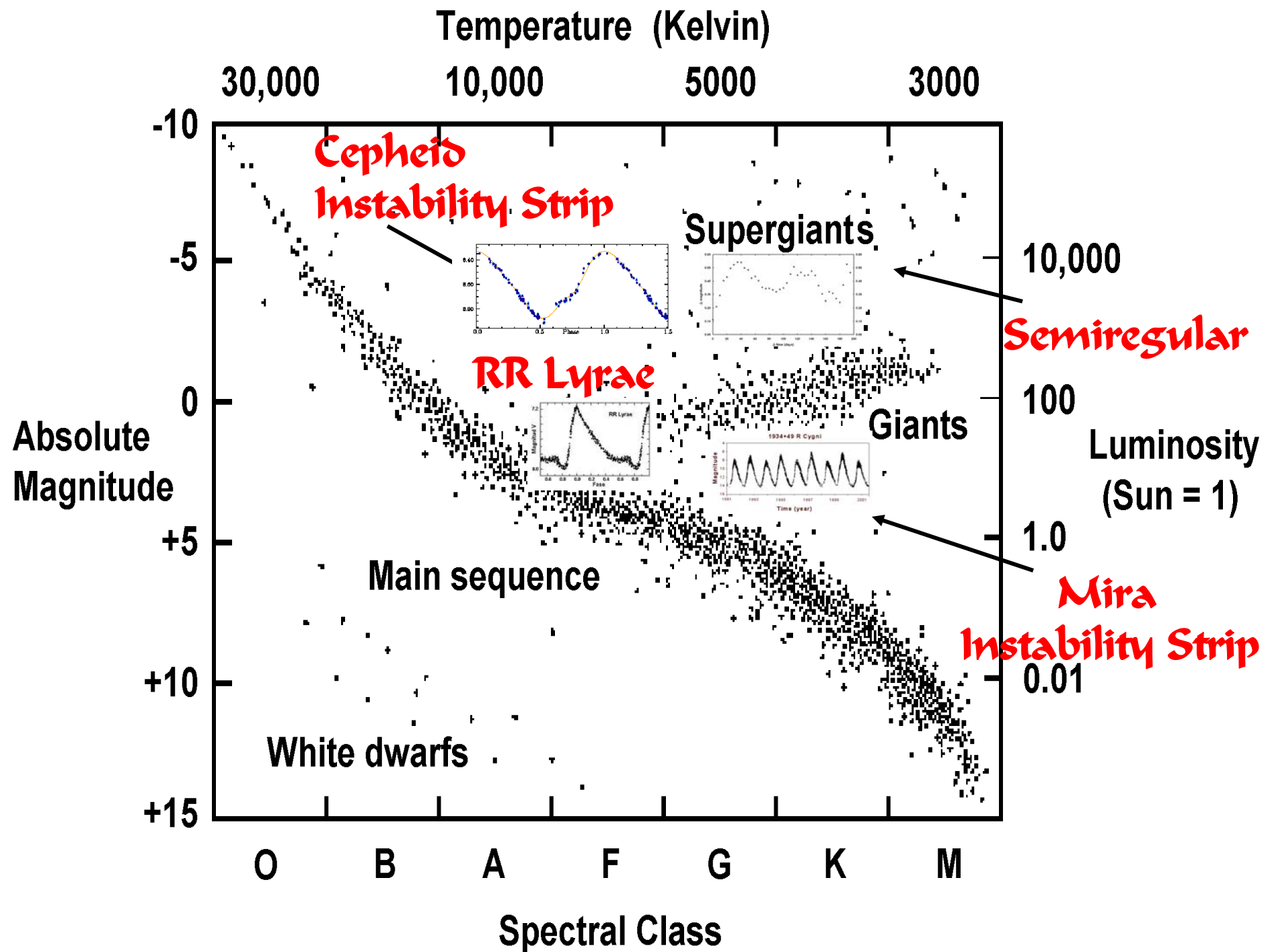




# Cepheid and RR Lyrae Variable Stars

Period-Luminosity Relationship and The Distance Modulus:

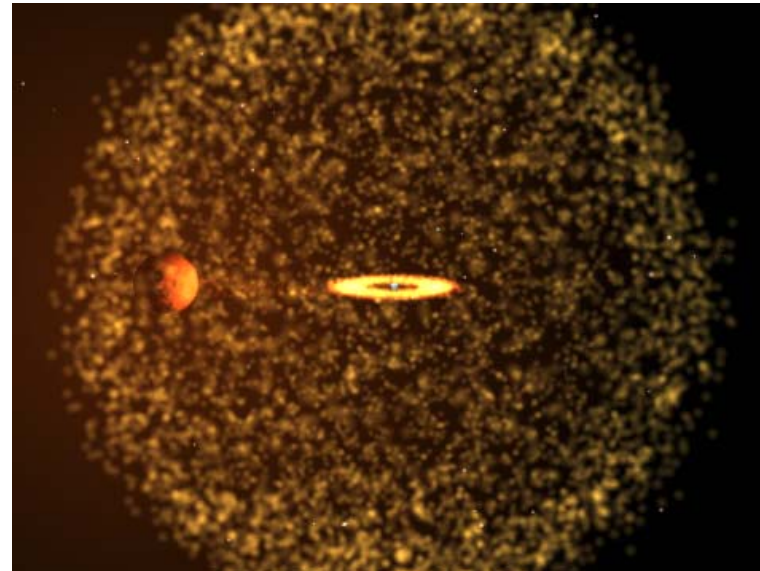
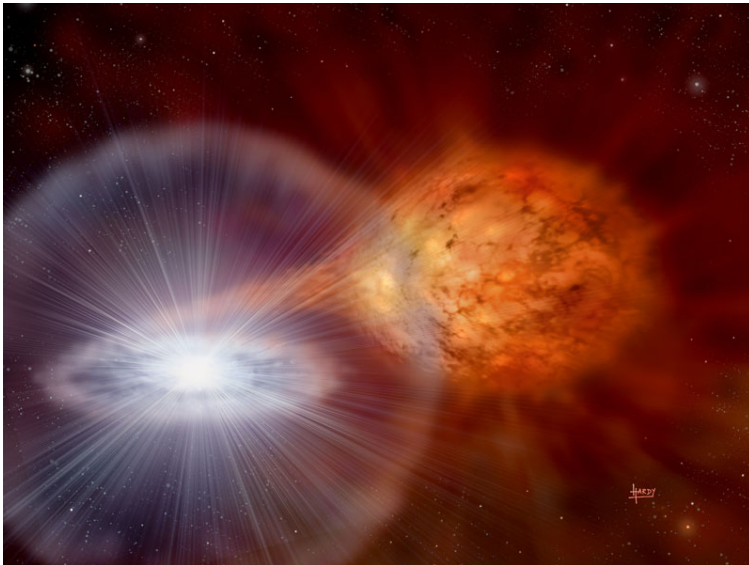
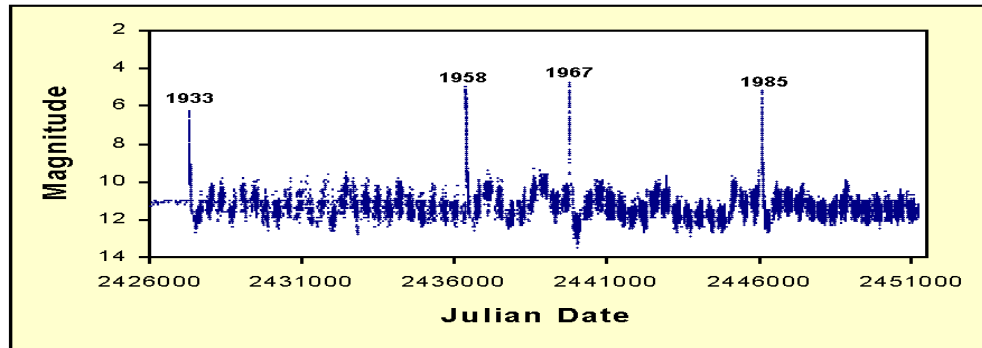




# B. Cataclysmic (Eruptive) Variables

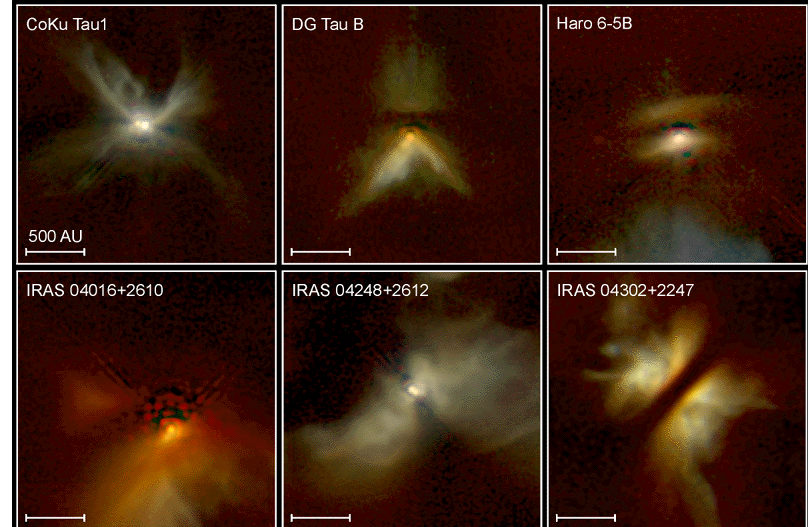
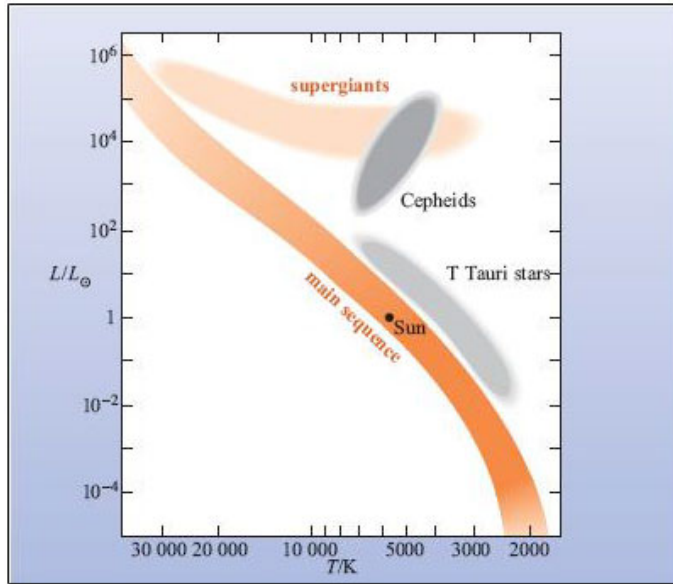
## 1) Recurrent Novae [1-200+ days, 7 - 16 mag]

### RS Ophiuchi

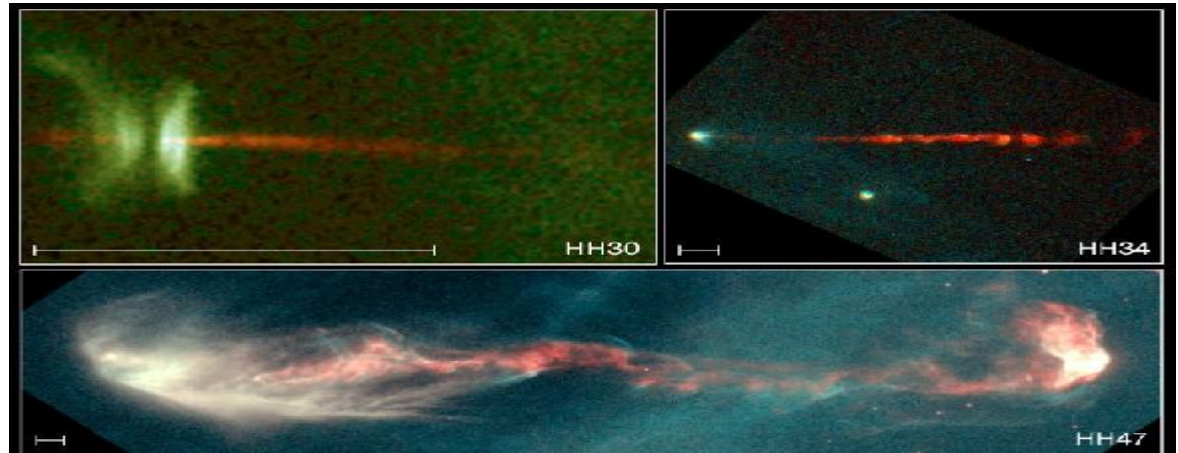


# 2) T Tauri - pre main sequence proto-star

## T Tauri [irregular and unpredictable]



**Young Stellar Disks in Infrared**  
PRC99-05a • STScI OPO  
D. Padgett (IPAC/Caltech), W. Brandner (IPAC), K. Stapelfeldt (JPL) and NASA  
HST • NICMOS



**Jets from Young Stars**  
PRC95-24a • ST ScI OPO • June 6, 1995  
C. Burrows (ST ScI), J. Hester (AZ State U.), J. Morse (ST ScI), NASA  
HST • WFPC2

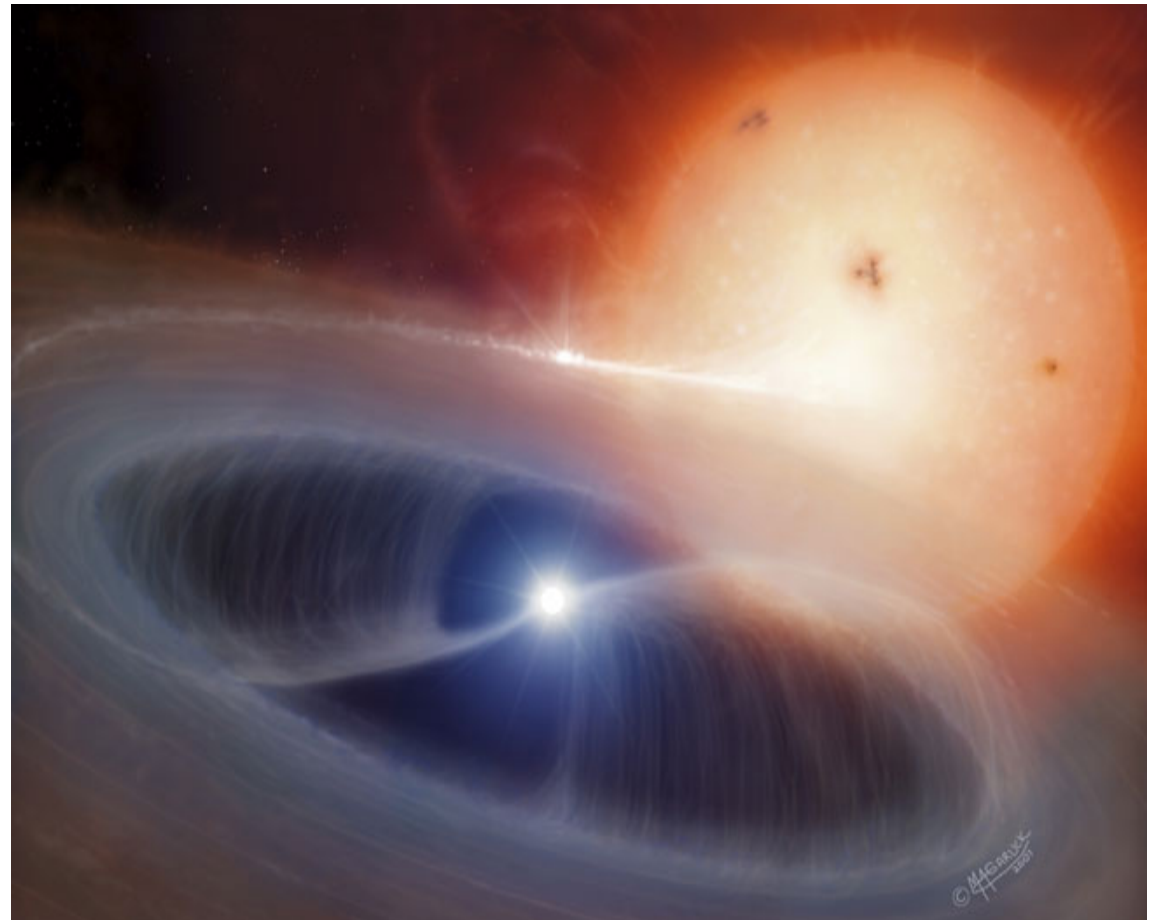
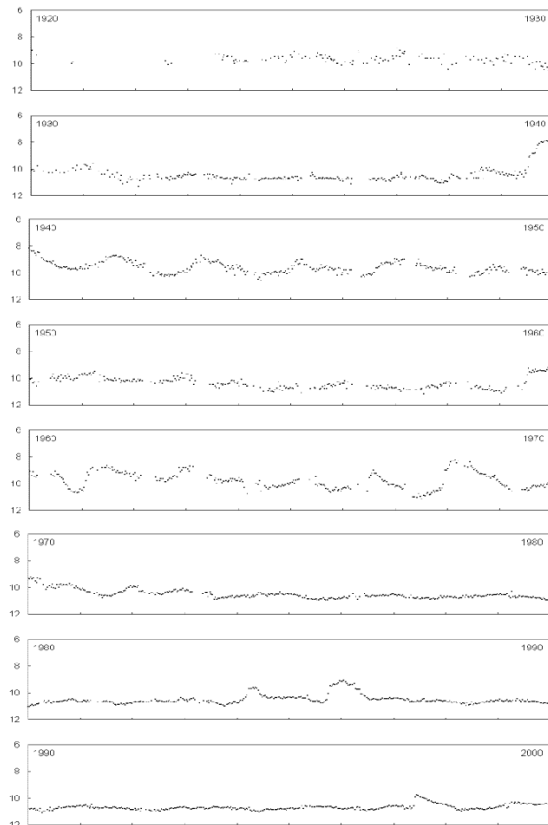
# 3) Symbiotic

Close Binary System - red giant and massive blue star  
both embedded in nebulosity

**Z Andromedae**

[Semi-periodic, up to 3 mag]

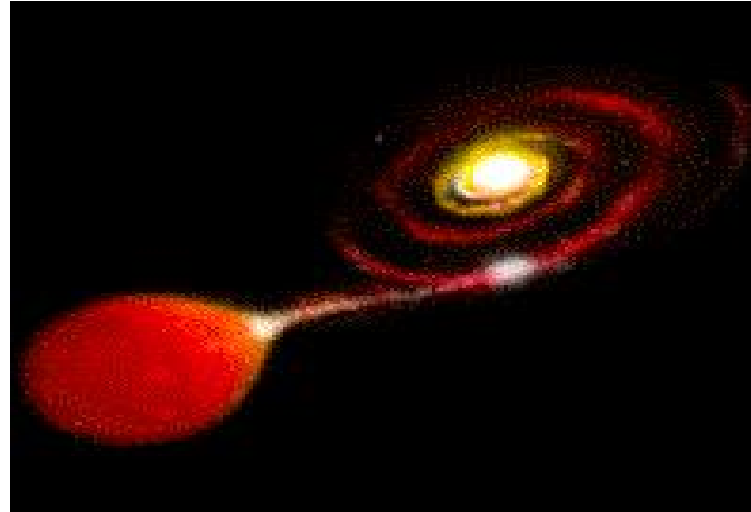
2328+48 Z Andromedae (Symbiotic)  
1920-2000 (10-day means)



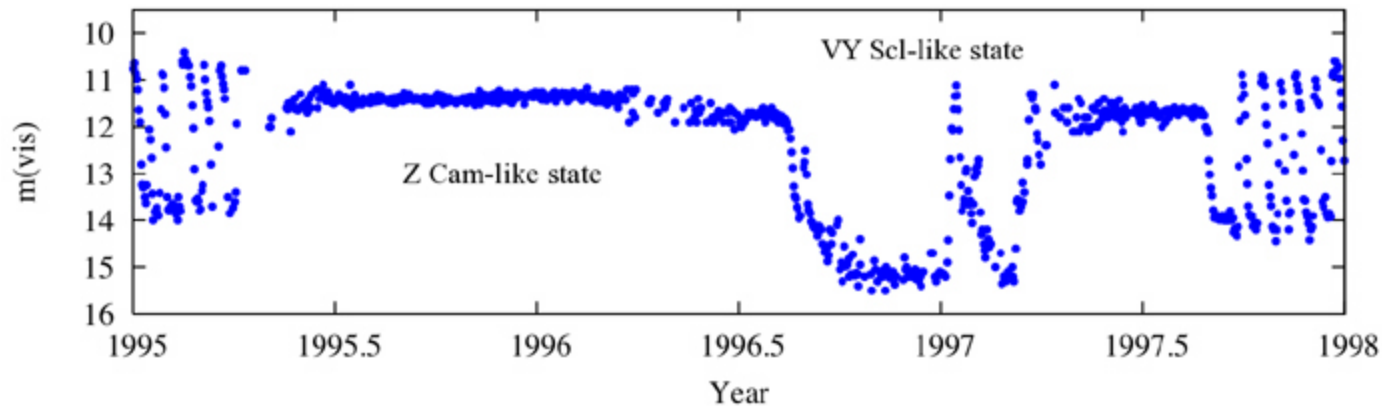


4) **V Geminorum** [30-500 days, 2-6 mag]  
after intervals of quiescence suddenly brighten  
for 5 - 20 days - in a dwarf novae type system

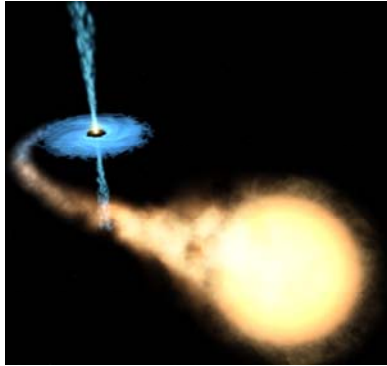
**RX Andromedae**



RX Andromedae (1995-1998)

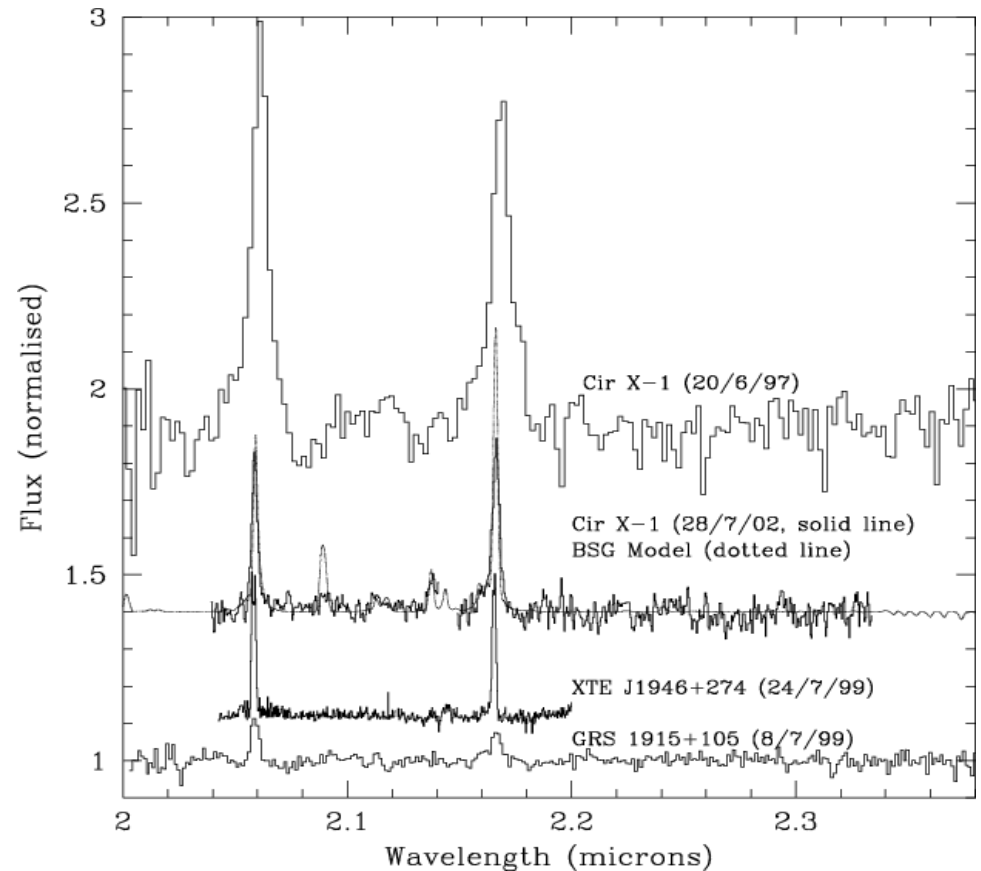
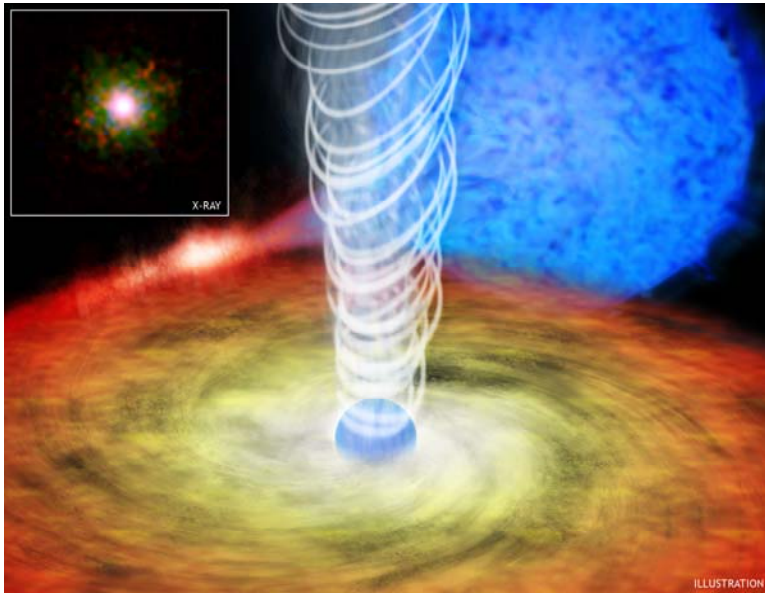


# 5) X-Ray Binaries - Close Binary Systems



**White Dwarf, Neutron Star, or Black Hole accreting material from a Companion Star**

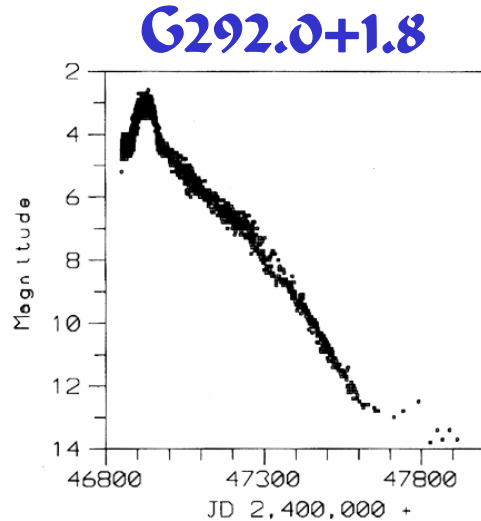
## Circinus X-1





# 6) Supernovae

## a) Type II - Core Collapse of a Massive Star



### Supernovas: When Stars Die (10-30-2006)

When a star explodes, it leaves behind a debris field of stellar material and high-energy particles known as a supernova remnant. Astronomers use Chandra to study these remnants that can produce intense X-ray radiation for thousands of years. Supernova remnants are responsible for seeding cloud that formed our Sun, planets, and ultimately us with elements like nitrogen and oxygen.

- [View Video Podcast](#) (22.2 MB, Runtime: 4:39)

- [Listen to Audio Only](#)

- [Transcript](#)



### Until Their Dying Day: Stars on the Brink (09-26-2006)

Supernovas are the remnants of catastrophic explosions, and they are among the favorite targets of scientists who use Chandra, for good reason too. Supernovas and their remnants have proven to be extremely important in understanding topics ranging from the birth of our Solar System to the history and composition of the Universe itself.

- [View Video Podcast](#) (18.1 MB, Runtime: 4:40)

- [Listen to Audio Only](#)

- [Transcript](#)

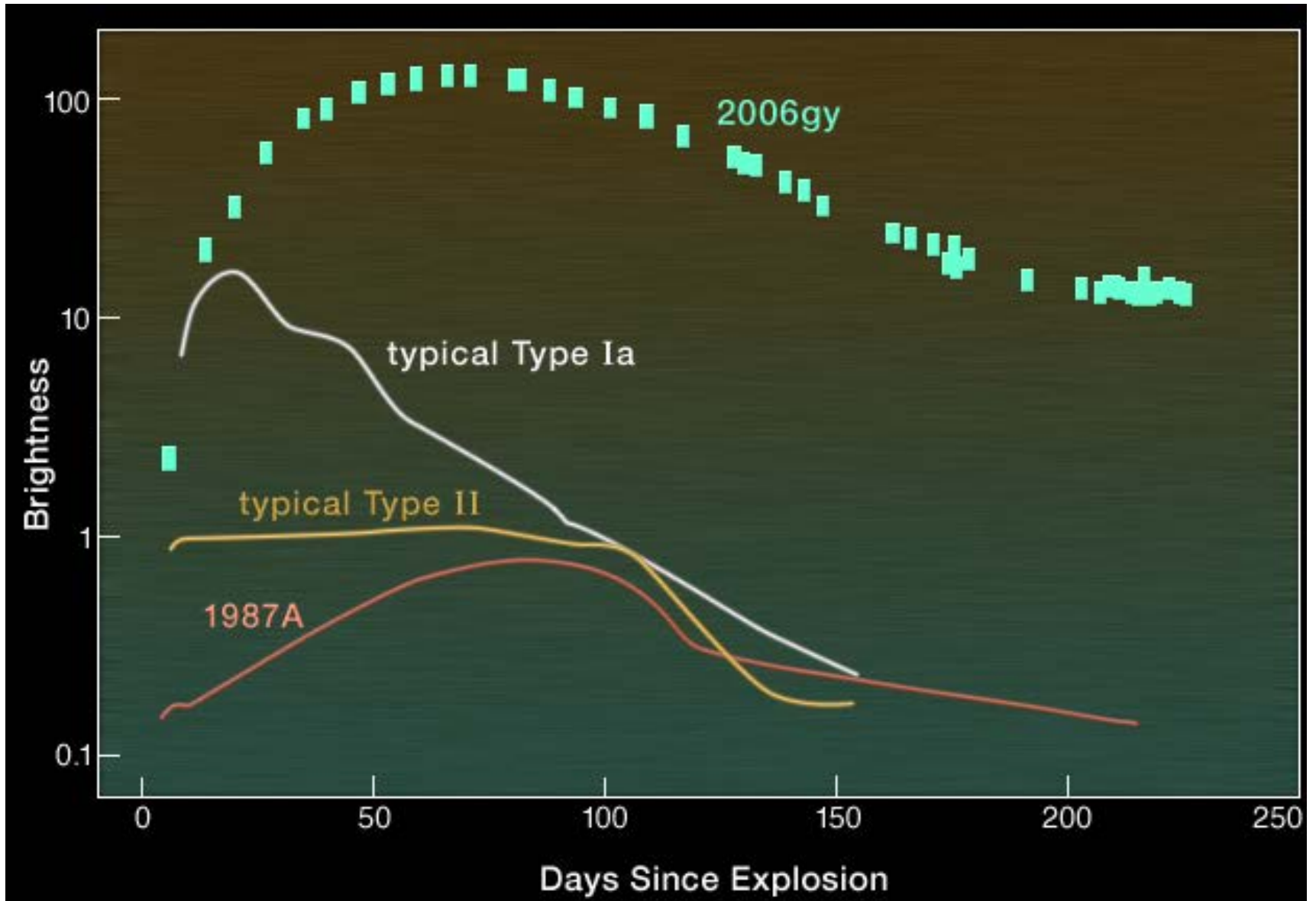


# b) Type Ia - Thermonuclear Destruction of a White Dwarf in a Binary System

SN 1006

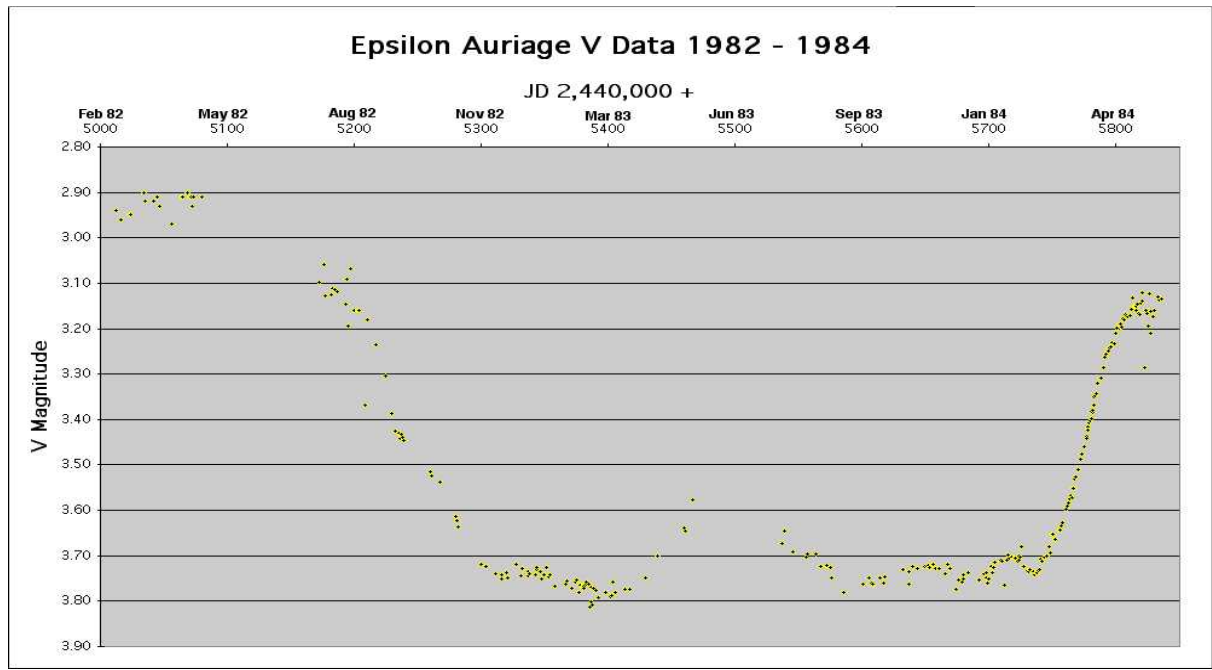
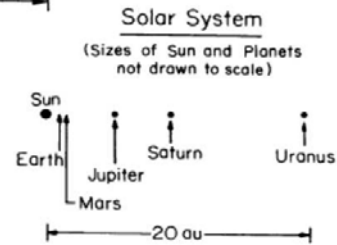
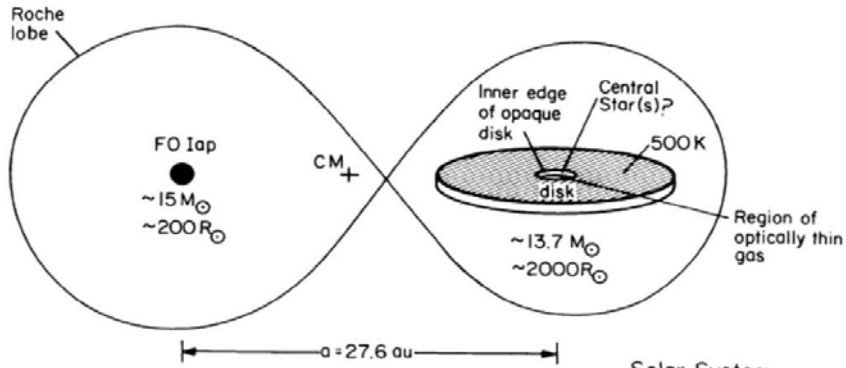
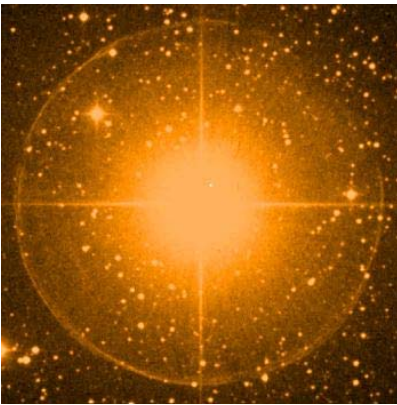


# Supernovae Light Curves



# C. Eclipsing Binaries

## Epsilon Aurigae



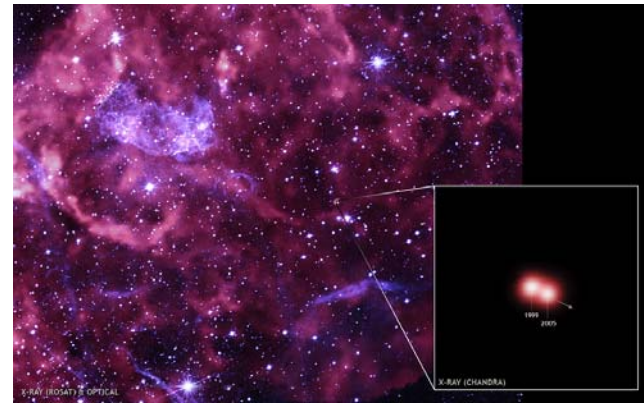
[http://www.aavso.org/news/press\\_epsaur.shtml](http://www.aavso.org/news/press_epsaur.shtml)



## Other Deep Sky Objects:

**RX J0822-4300**

**Neutron star in Puppis A SNR**



**NGC 2440**

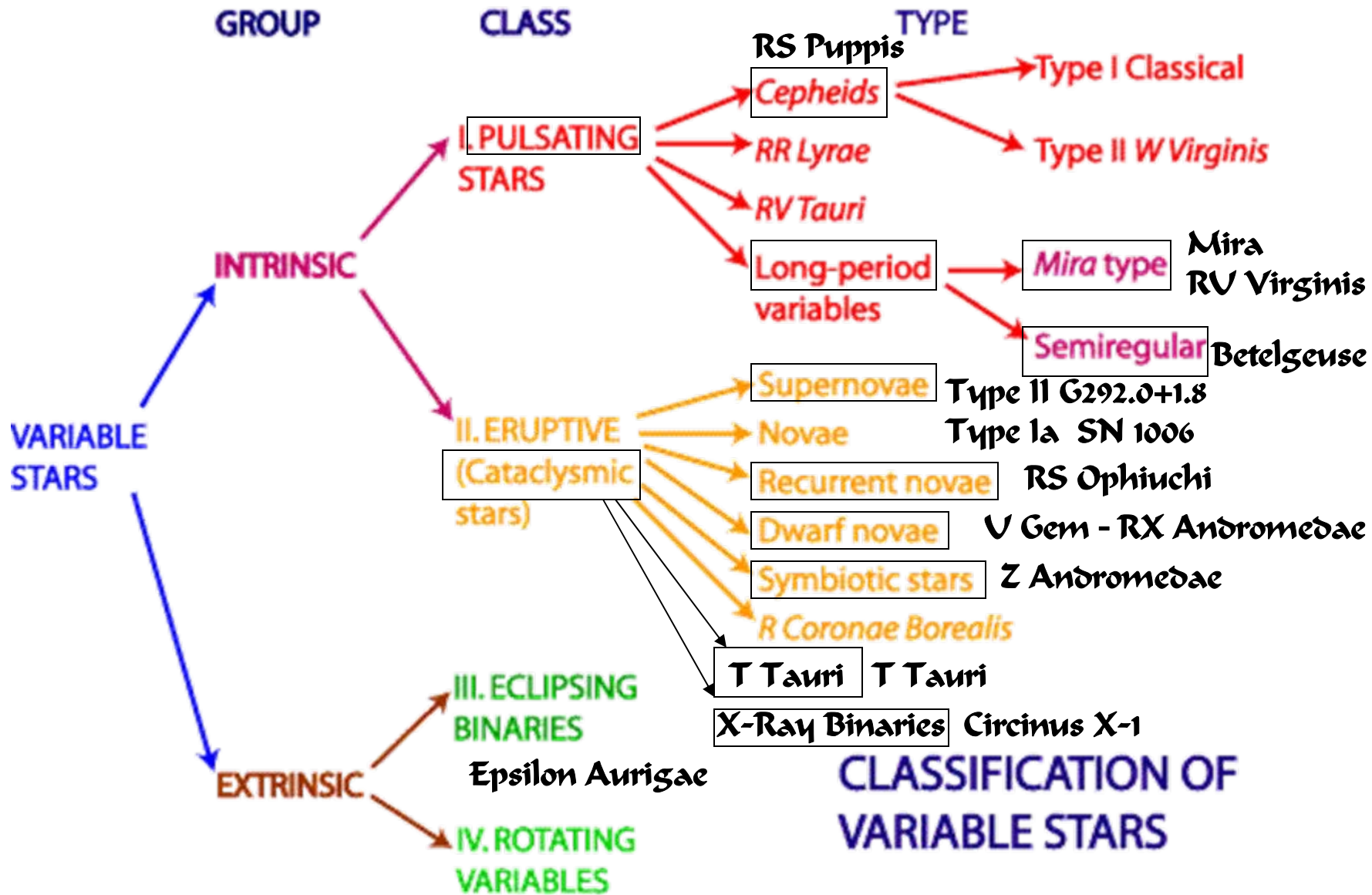
**Planetary Nebula**



**Hinds Variable Nebula**

**gas and dust surrounding T Tauri**

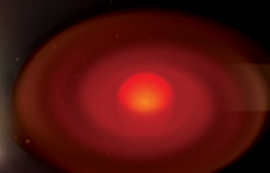




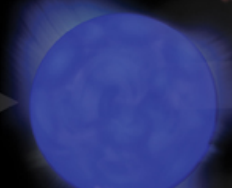
**CLASSIFICATION OF VARIABLE STARS**

MASS

TIME

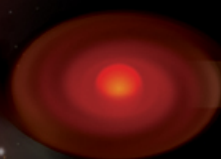


Protostar



Blue Supergiant

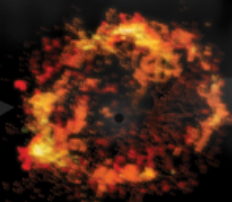
Black Hole



Protostar



Blue Supergiant



Supernova

Black Hole



Protostar



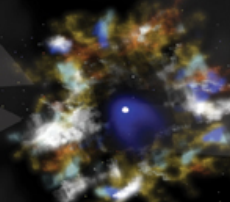
Blue Supergiant



Red Giant  
(with stellar winds)

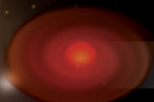


Blue Supergiant



Supernova  
(with neutron star)

Neutron Star



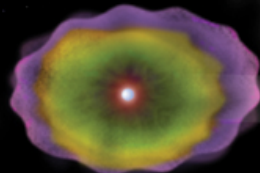
Protostar



Solar  
Type Star

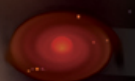


Red Giant



Planetary Nebula

White Dwarf



Protostar



Red Dwarf



Red Dwarf

White Dwarf



Protostar



Brown Dwarf



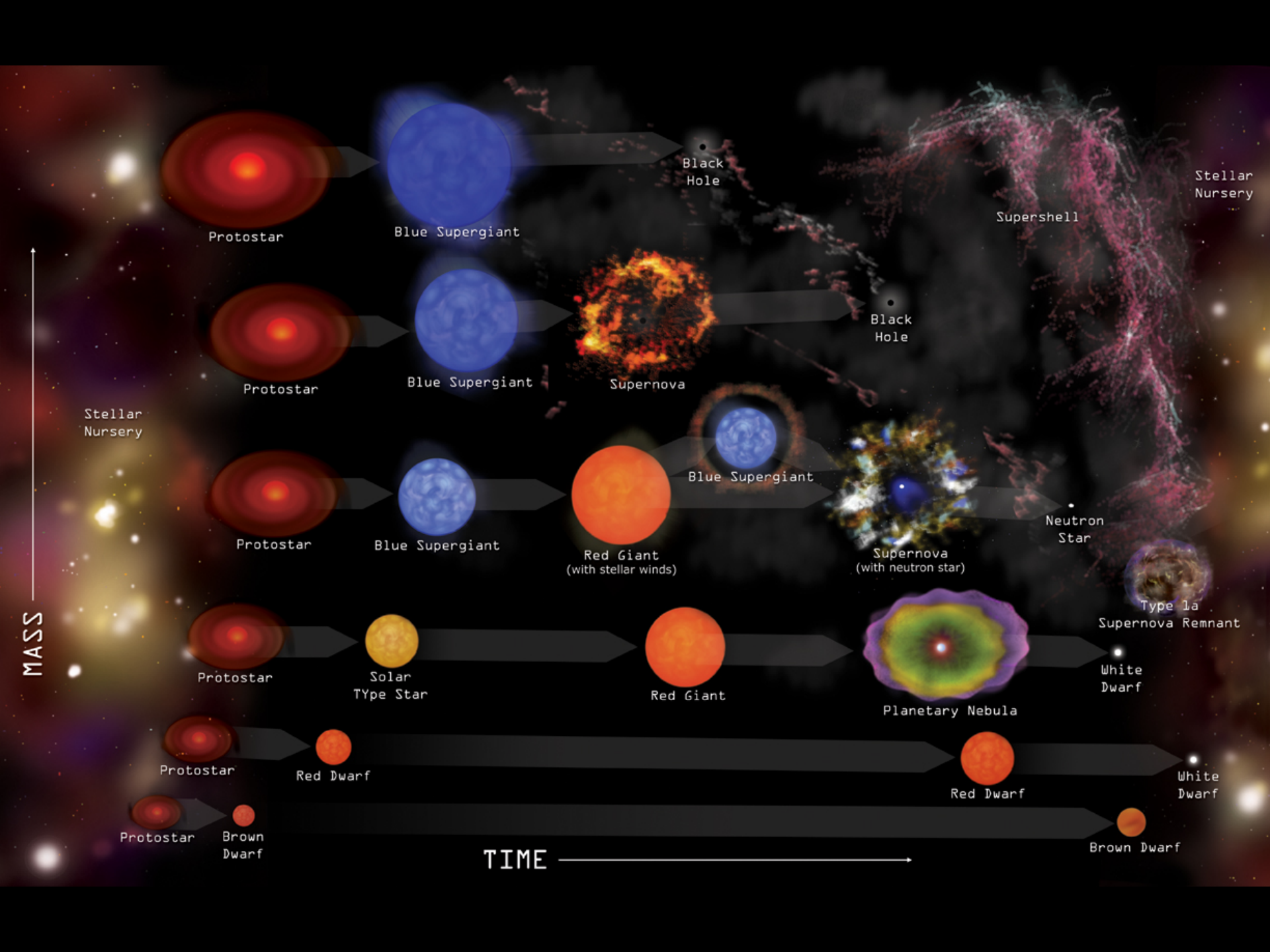
Brown Dwarf

Stellar Nursery

Supershell

Stellar Nursery

Type Ia  
Supernova Remnant

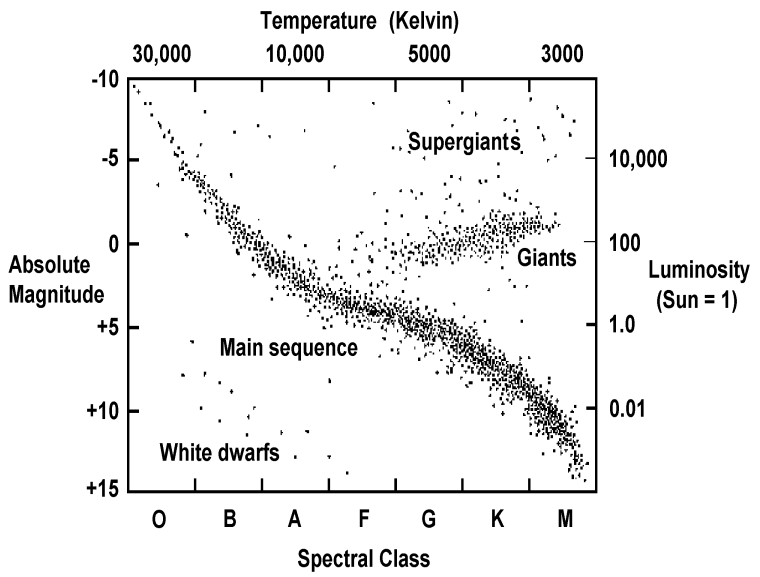
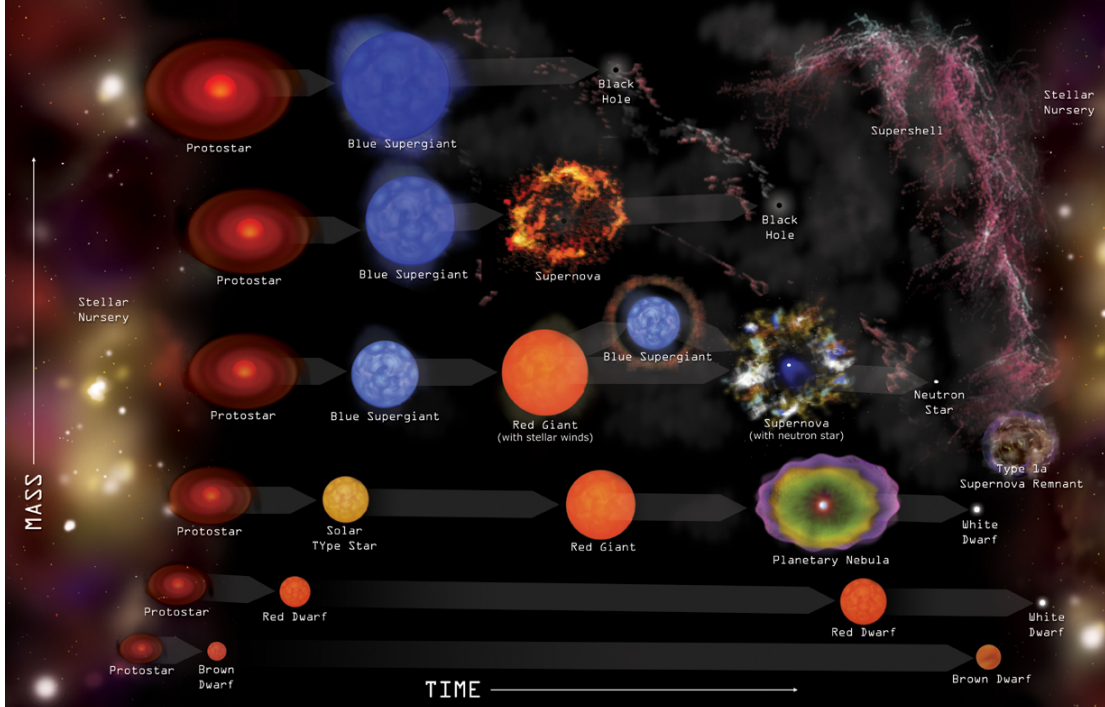
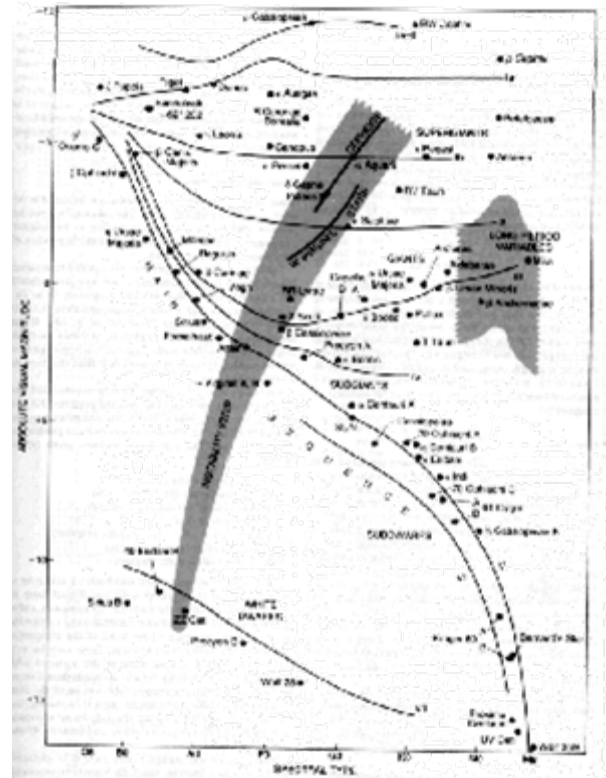


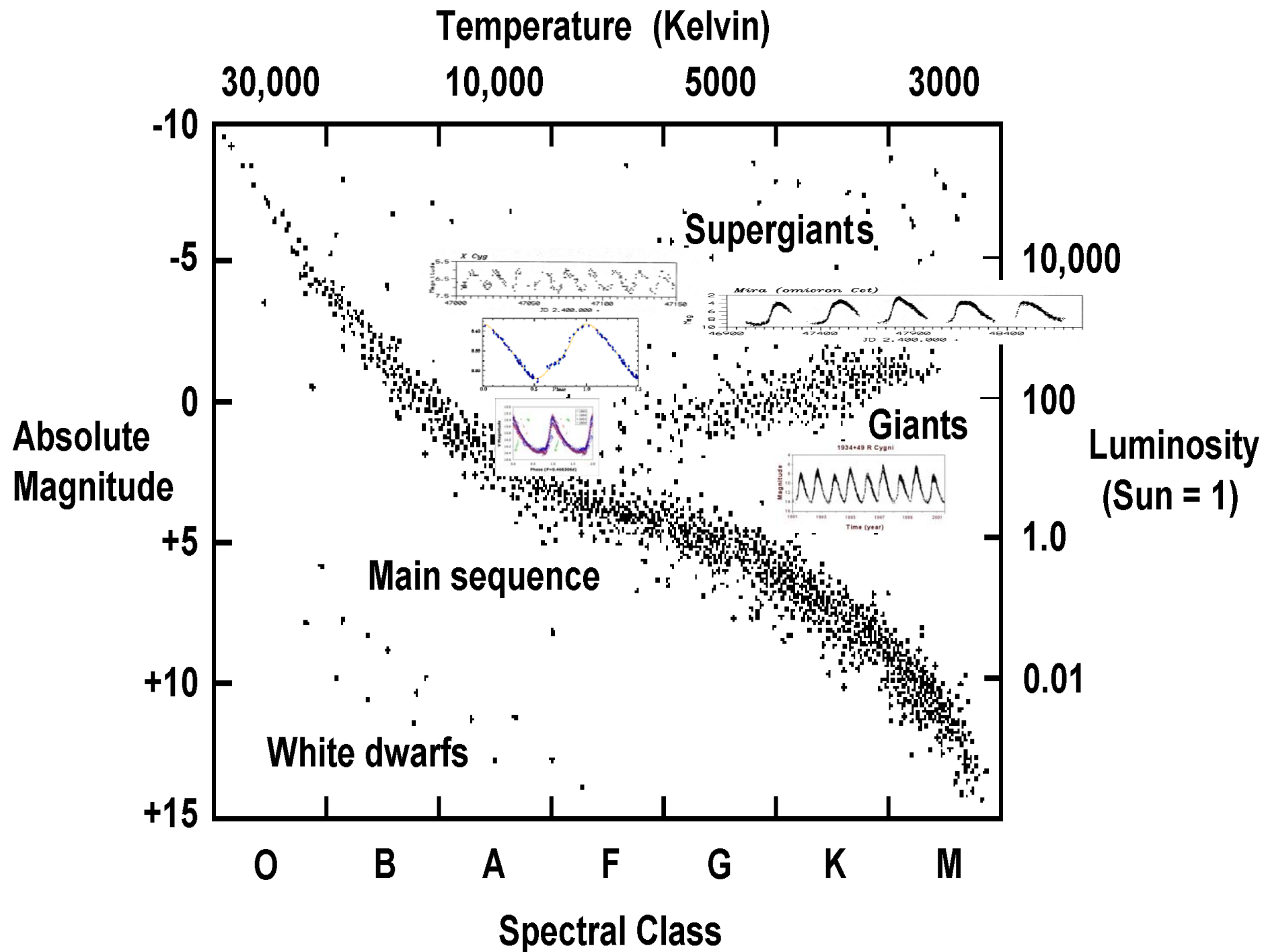


# Periodic Table of the Elements

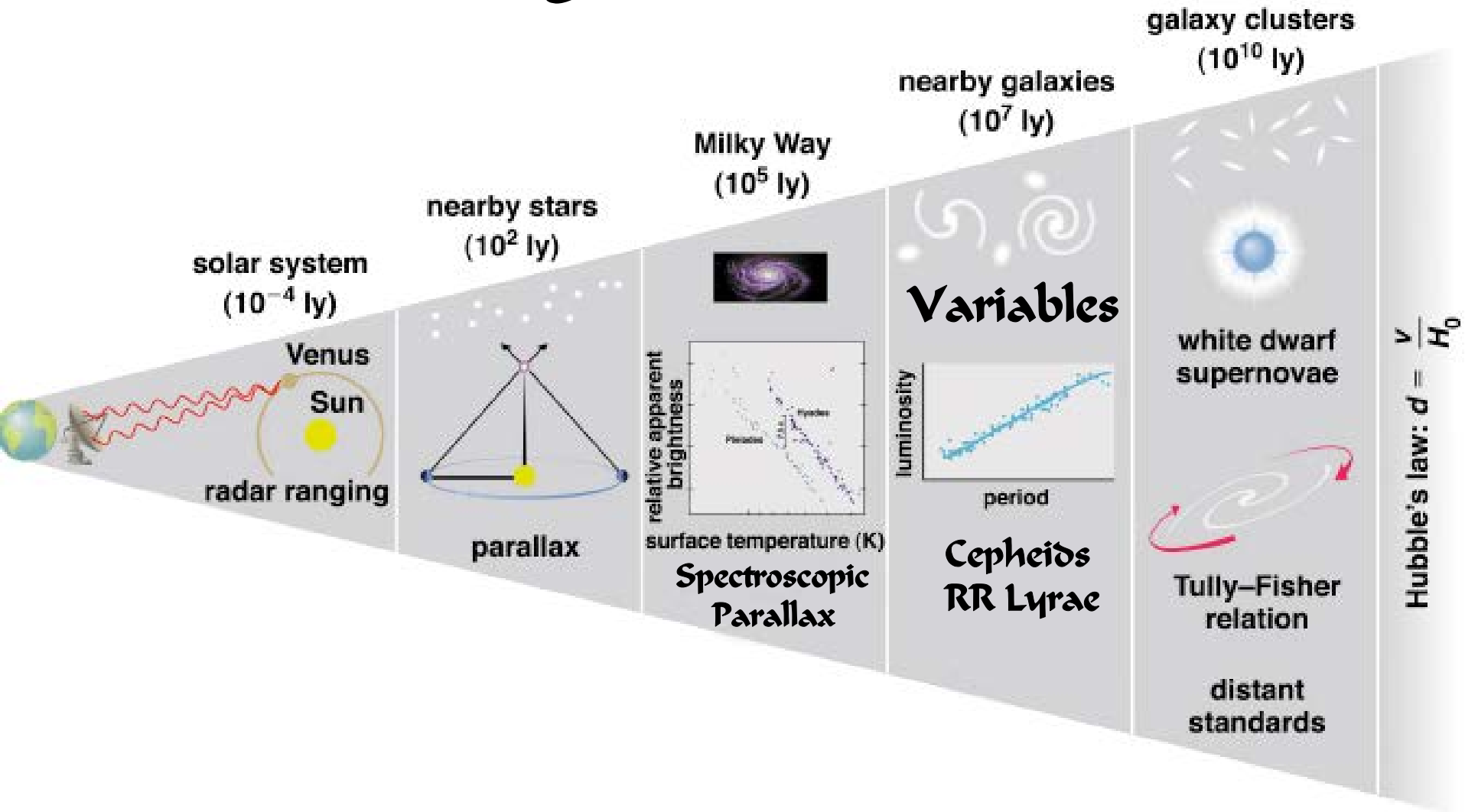
1 1A 1 <b>H</b> Hydrogen 1.00794	2 2A 2 <b>He</b> Helium 4.0026											13 3A 3 <b>B</b> Boron 10.811	14 4A 4 <b>C</b> Carbon 12.01115	15 5A 5 <b>N</b> Nitrogen 14.0067	16 6A 6 <b>O</b> Oxygen 15.9994	17 7A 7 <b>F</b> Fluorine 18.9984	18 8A 8 <b>Ne</b> Neon 20.179
3 1A 3 <b>Li</b> Lithium 6.941	4 2A 4 <b>Be</b> Beryllium 9.0122											5 3A 5 <b>Al</b> Aluminum 26.9815	6 4A 6 <b>Si</b> Silicon 28.086	7 5A 7 <b>P</b> Phosphorus 30.9738	8 6A 8 <b>S</b> Sulfur 32.064	9 7A 9 <b>Cl</b> Chlorine 35.453	10 8A 10 <b>Ar</b> Argon 39.948
11 1A 11 <b>Na</b> Sodium 22.98976	12 2A 12 <b>Mg</b> Magnesium 24.305											13 3A 13 <b>Ga</b> Gallium 69.72	14 4A 14 <b>Ge</b> Germanium 72.59	15 5A 15 <b>As</b> Arsenic 74.9216	16 6A 16 <b>Se</b> Selenium 78.96	17 7A 17 <b>Br</b> Bromine 79.904	18 8A 18 <b>Kr</b> Krypton 83.80
19 1A 19 <b>K</b> Potassium 39.0983	20 2A 20 <b>Ca</b> Calcium 40.08	21 3B 21 <b>Sc</b> Scandium 44.956	22 4B 22 <b>Ti</b> Titanium 47.88	23 5B 23 <b>V</b> Vanadium 50.942	24 6B 24 <b>Cr</b> Chromium 51.996	25 7B 25 <b>Mn</b> Manganese 54.938	26 8B 26 <b>Fe</b> Iron 55.847	27 9B 27 <b>Co</b> Cobalt 58.9332	28 10B 28 <b>Ni</b> Nickel 58.69	29 11B 29 <b>Cu</b> Copper 63.546	30 12B 30 <b>Zn</b> Zinc 65.37	31 13B 31 <b>Ga</b> Gallium 69.72	32 14B 32 <b>Ge</b> Germanium 72.59	33 15B 33 <b>As</b> Arsenic 74.9216	34 16B 34 <b>Se</b> Selenium 78.96	35 17B 35 <b>Br</b> Bromine 79.904	36 18B 36 <b>Kr</b> Krypton 83.80
37 1A 37 <b>Rb</b> Rubidium 85.4678	38 2A 38 <b>Sr</b> Strontium 87.62	39 3B 39 <b>Y</b> Yttrium 88.906	40 4B 40 <b>Zr</b> Zirconium 91.224	41 5B 41 <b>Nb</b> Niobium 92.906	42 6B 42 <b>Mo</b> Molybdenum 95.94	43 7B 43 <b>Tc</b> Technetium (98)	44 8B 44 <b>Ru</b> Ruthenium 101.07	45 9B 45 <b>Rh</b> Rhodium 102.905	46 10B 46 <b>Pd</b> Palladium 106.4	47 11B 47 <b>Ag</b> Silver 107.868	48 12B 48 <b>Cd</b> Cadmium 112.411	49 13B 49 <b>In</b> Indium 114.818	50 14B 50 <b>Sn</b> Tin 118.710	51 15B 51 <b>Sb</b> Antimony 121.757	52 16B 52 <b>Te</b> Tellurium 127.603	53 17B 53 <b>I</b> Iodine 126.905	54 18B 54 <b>Xe</b> Xenon 131.29
55 1A 55 <b>Cs</b> Cesium 132.905	56 2A 56 <b>Ba</b> Barium 137.327	57 3B 57 <b>La</b> Lanthanum 138.905	58 4B 58 <b>Ce</b> Cerium 140.12	59 5B 59 <b>Pr</b> Praseodymium 140.907	60 6B 60 <b>Nd</b> Neodymium 144.24	61 7B 61 <b>Pm</b> Promethium (145)	62 8B 62 <b>Sm</b> Samarium 150.35	63 9B 63 <b>Eu</b> Europium 151.96	64 10B 64 <b>Gd</b> Gadolinium 157.25	65 11B 65 <b>Tb</b> Terbium 158.925	66 12B 66 <b>Dy</b> Dysprosium 162.50	67 13B 67 <b>Ho</b> Holmium 164.930	68 14B 68 <b>Er</b> Erbium 167.26	69 15B 69 <b>Tm</b> Thulium 168.934	70 16B 70 <b>Yb</b> Ytterbium 173.04	71 17B 71 <b>Lu</b> Lutetium 174.967	
87 1A 87 <b>Fr</b> Francium (223)	88 2A 88 <b>Ra</b> Radium (226.0254)	89 3B 89 <b>Ac</b> Actinium (227.0277)	90 4B 90 <b>Th</b> Thorium 232.038	91 5B 91 <b>Pa</b> Protactinium (231.0359)	92 6B 92 <b>U</b> Uranium 238.03	93 7B 93 <b>Np</b> Neptunium (237.0482)	94 8B 94 <b>Pu</b> Plutonium (244)	95 9B 95 <b>Am</b> Americium (243)	96 10B 96 <b>Cm</b> Curium (247)	97 11B 97 <b>Bk</b> Berkelium (247)	98 12B 98 <b>Cf</b> Californium (251)	99 13B 99 <b>Es</b> Einsteinium (252)	100 14B 100 <b>Fm</b> Fermium (257)	101 15B 101 <b>Md</b> Mendelevium (258)	102 16B 102 <b>No</b> Nobelium (259)	103 17B 103 <b>Lr</b> Lawrencium (260)	

Note: Elements 113-118 are not currently known. They are shown in the table at their expected positions for information only.



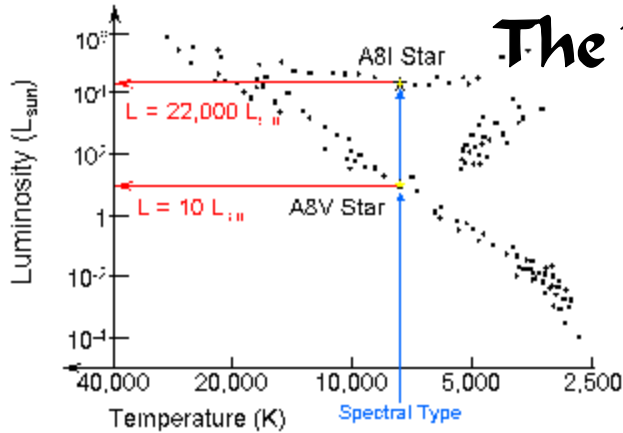


# Cosmological Distances

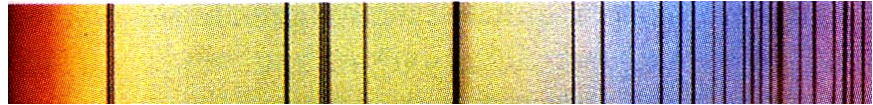


# Cosmological Distances

## → Spectroscopic Parallax



The Distance Modulus:  $M = m - 5 \log_{10} \frac{r}{10}$



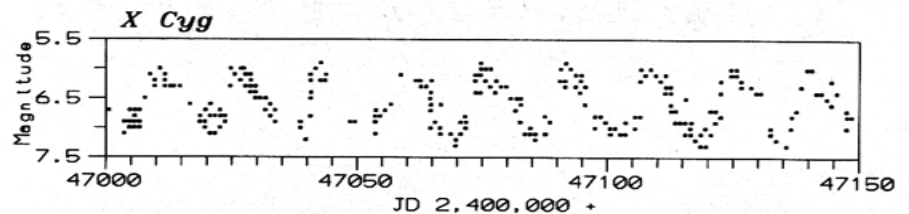
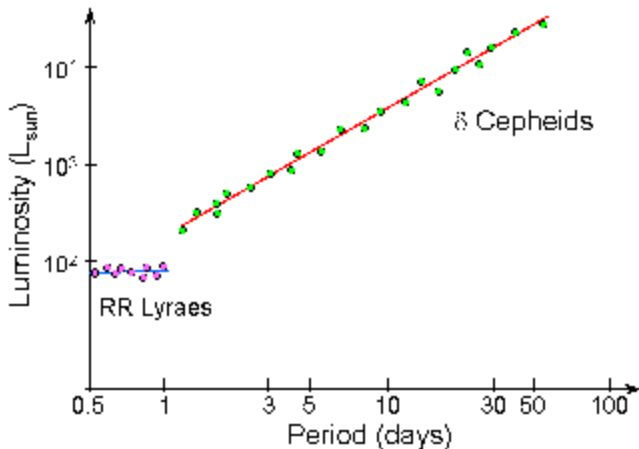
10

## → Cepheids

The Distance Modulus:  $M = m - 5 \log_{10} \frac{r}{10}$

Period-Luminosity Relationship

10



# Cosmological Distances & Candles

## → Type Ia Supernovae - Standard Candle



$$M_v = -19.5$$

The Distance Modulus:  $M = m - 5 \log_{10} \frac{r}{10}$

# Basic Equations and Relationships

The Distance Modulus:  $M = m - 5 \log_{10} \frac{r}{10}$

Kepler's 3<sup>rd</sup> Law:  $(M_A + M_B) = \frac{a^3}{p^2}$

$v = \frac{d}{t}$  ;  $a = \frac{v}{t}$  ;  $2\pi a = vP$  ;  $F_c = ma_c$  ;  $a_c = \frac{v^2}{r} = r\omega^2$

1 pc = 206,265 au = 3.26 ly =  $3.08 \times 10^{16}$  m

1° = 60 arcmin = 60' ; 1' = 60 arcsec = 60''

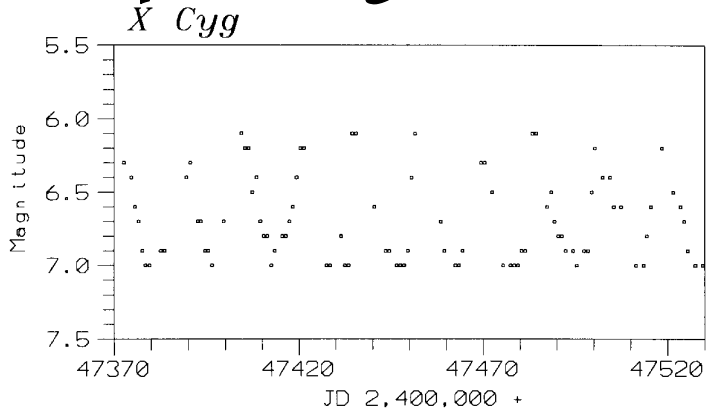
Inverse Square Law:  $L = 1/r^2$

Circumference, Area, Surface Area, and Volume of a Sphere

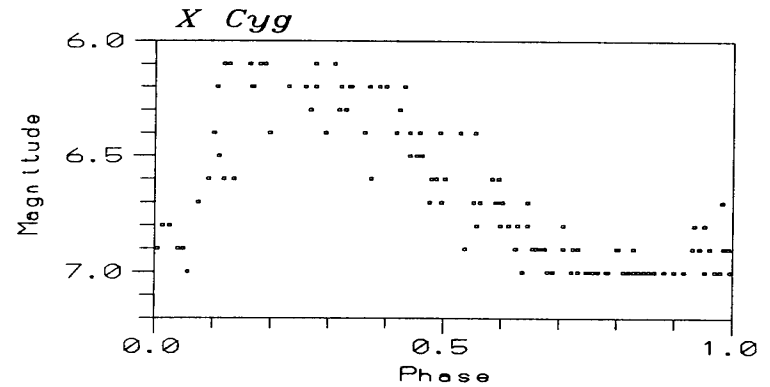
**REARRANGE ALL EQUATIONS FOR EACH VARIABLE**

# Phase Diagrams

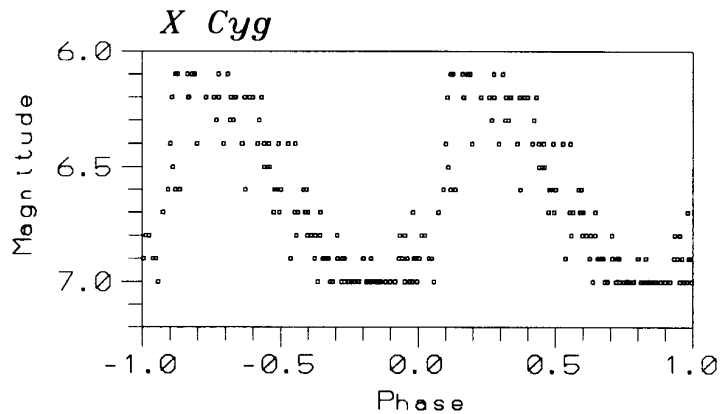
## 1) Cepheid Light Curve



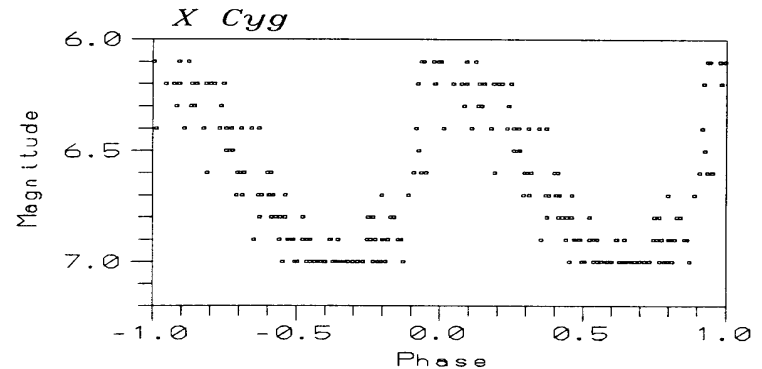
## 2) Superposition of Periods



## 3) Same Data Plotted Twice



## 4) Same data starting at Maxima

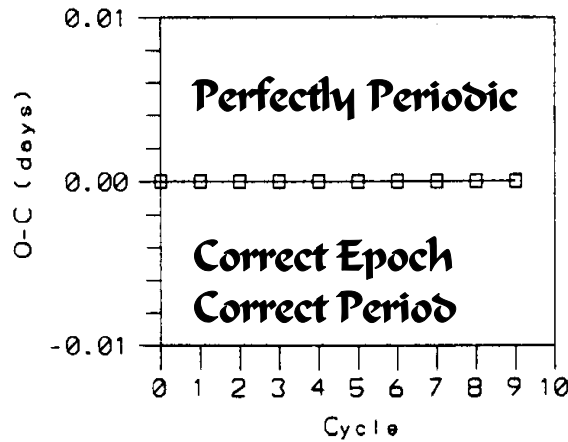




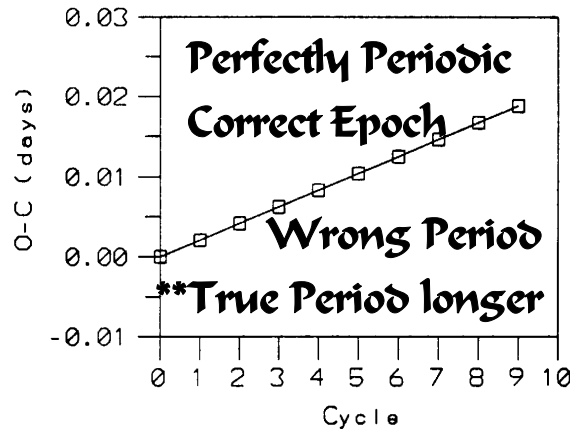
# O - C Diagrams (Observed minus Calculated)

Theory Matches Observation

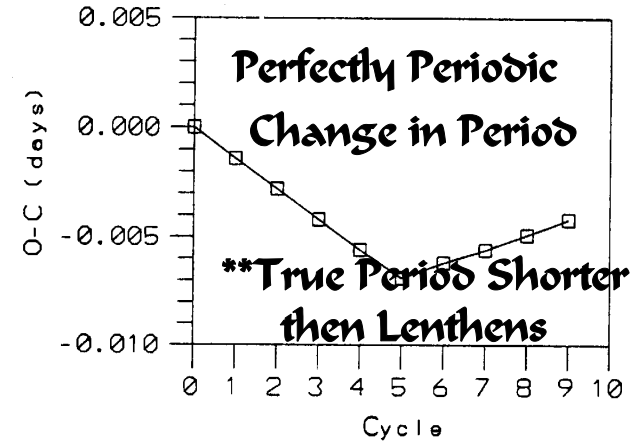
*Clock No. 1*



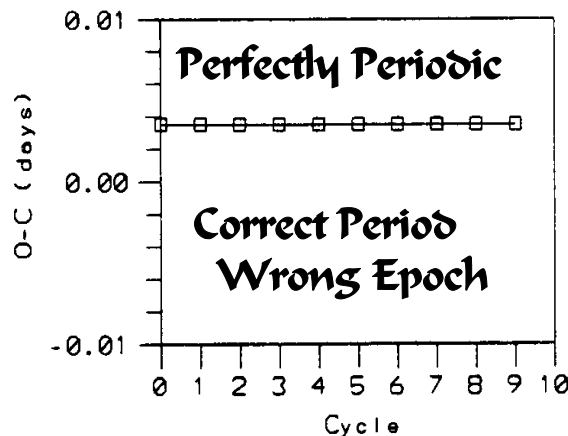
*Clock No. 3*



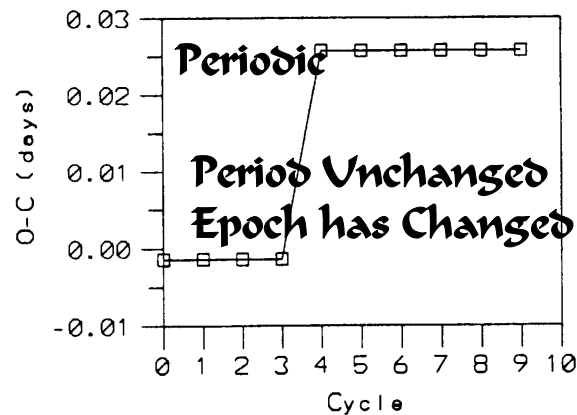
*Clock No. 5*



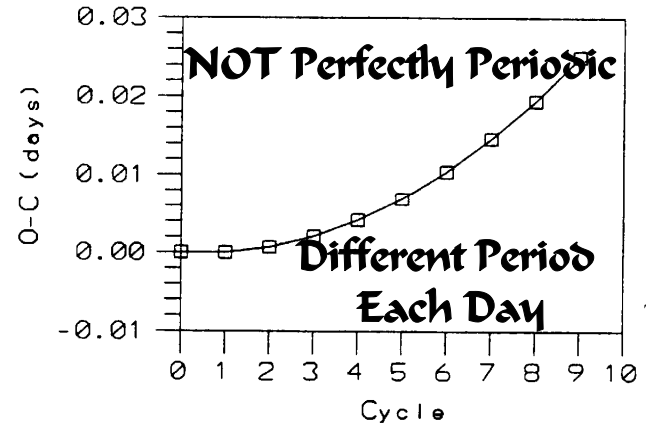
*Clock No. 2*



*Clock No. 4*



*Clock No. 6*



**\*\* The slope of each line is the difference between its period and the estimated period.**

## Variable Stars

Stars appear to shine with a constant light; however, thousands of stars vary in brightness. The brightness that a star appears to have (apparent magnitude) from our perspective here on Earth depends upon its distance from Earth and its actual intrinsic brightness (absolute magnitude.) The behavior of stars that vary in magnitude (brightness) - known as variable stars - can be studied by measuring their changes in brightness over time and plotting the changes on a graph called a light curve. Amateur astronomers around the world observe variable stars and assist professional astronomers by sending their data to variable star organizations, such as the American Association of Variable Star Observers ([AAVSO](#)) in Cambridge, Massachusetts. The behavior of some variable stars can be observed with the unaided eye or binoculars. Measuring and recording the changes in apparent magnitude and drawing the resulting light curves will allow you to begin to unravel the stories of the often turbulent and always exciting lives of variable stars. The collection and study of variable star data requires the ability to estimate the apparent magnitudes of stars. The two activities that follow will assist you in acquiring the skill of estimating the magnitudes of variable stars.

The two activities, Stellar Heartbeats and A Variable Star in Cygnus, have been adapted from the "[Hands-On-Astrophysics](#), Variable Stars in Math, Science, and Computer Education" curriculum project developed and published by the American Association of Variable Star Observers (AAVSO.)

**Activity #1:** Stellar Heartbeats [html](#) | [flash](#) | [pdf](#) | [ppt](#)

**Activity #2:** A Variable Star in Cygnus [html](#) | [flash](#) | [pdf](#) | [ppt](#)

**Alignment of Performance Task with National Standards:** [html](#) | [pdf](#)

### Useful Resources:

- ▶ [Types of Variable Stars](#) (at AAVSO)
- ▶ [Estimating Magnitudes Using Interpolation](#) (at AAVSO)

### CLASS ACTIVITIES

#### BACKGROUND

#### GALACTIC NAVIGATION

#### CHANDRA 101

#### TRACKING CHANDRA

#### ASK AN EXPERT

### INTERACTIVE GAMES

#### PRINT MATERIALS

#### EDUCATION LINKS

### WEB SITE TOOLS

#### CHRONICLES

#### EMAIL NEWSLETTER

#### SITE MAP

#### NEW & NOTEWORTHY

#### IMAGE USE POLICY

#### QUESTIONS & ANSWERS

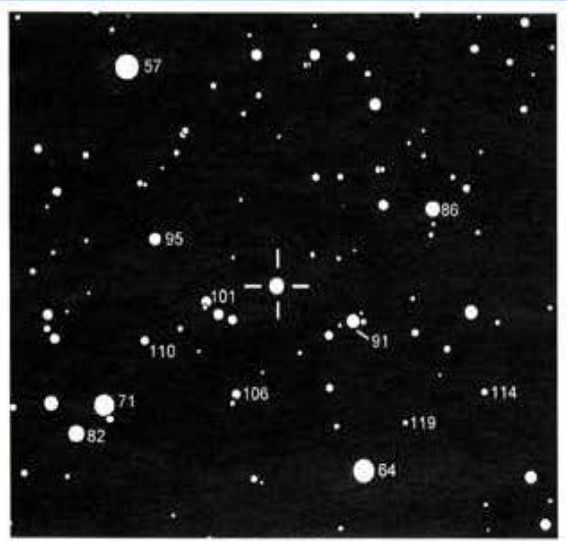
#### GLOSSARY OF TERMS

#### DOWNLOAD GUIDE



ACTIVITY #1 - STELLAR HEARTBEATS

Recording Stellar Heartbeats



JD 2449050

next image >

Estimate the magnitude of your variable star on the first picture of the star field using the magnitudes of the stars around it. Proceed through each of the pictures and place your estimated magnitude next to the corresponding JD in the table provided.

Julian Date	Magnitude
JD 2449050	
JD 2449110	
JD 2449150	
JD 2449180	
JD 2449240	
JD 2449300	
JD 2449350	
JD 2449375	
JD 2449435	
JD 2449500	
JD 2449540	
JD 2449635	
JD 2449700	
JD 2449740	
JD 2449760	
JD 2449800	
JD 2449870	
JD 2449950	

CLOSE

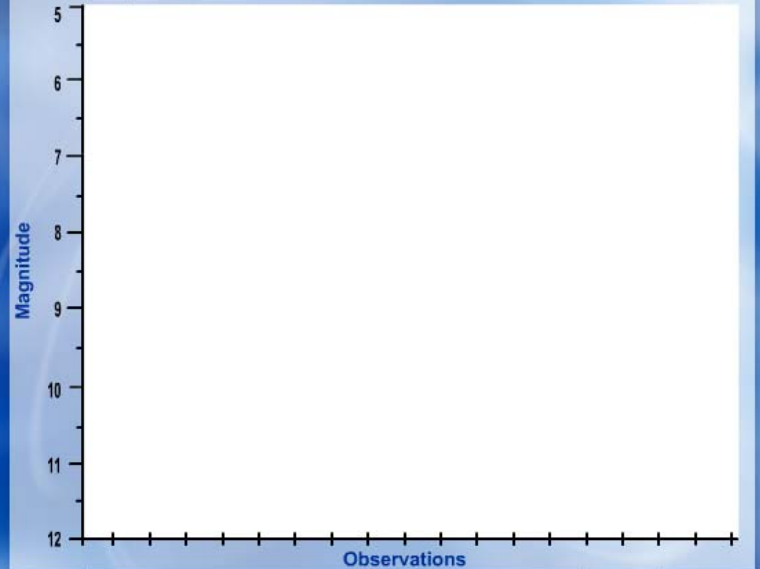
◀ BACK NEXT ▶

ACTIVITY #1 - STELLAR HEARTBEATS

JD 2449050 JD 2449110 JD 2449150 JD 2449180 JD 2449240 JD 2449300 JD 2449350 JD 2449375 JD 2449435

JD 2449500 JD 2449540 JD 2449635 JD 2449700 JD 2449740 JD 2449760 JD 2449800 JD 2449870 JD 2449950

Study the resulting light curve. Does this variable star show periodic behavior? Is this the light curve for a Cepheid variable star?



CLOSE

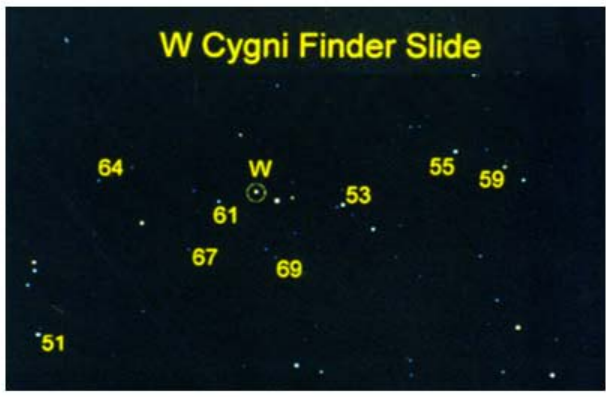
PRINT ◀ BACK

- Class Activities
- Background
- Interactive Games
- Printable Materials
- Links & Resources
- Search

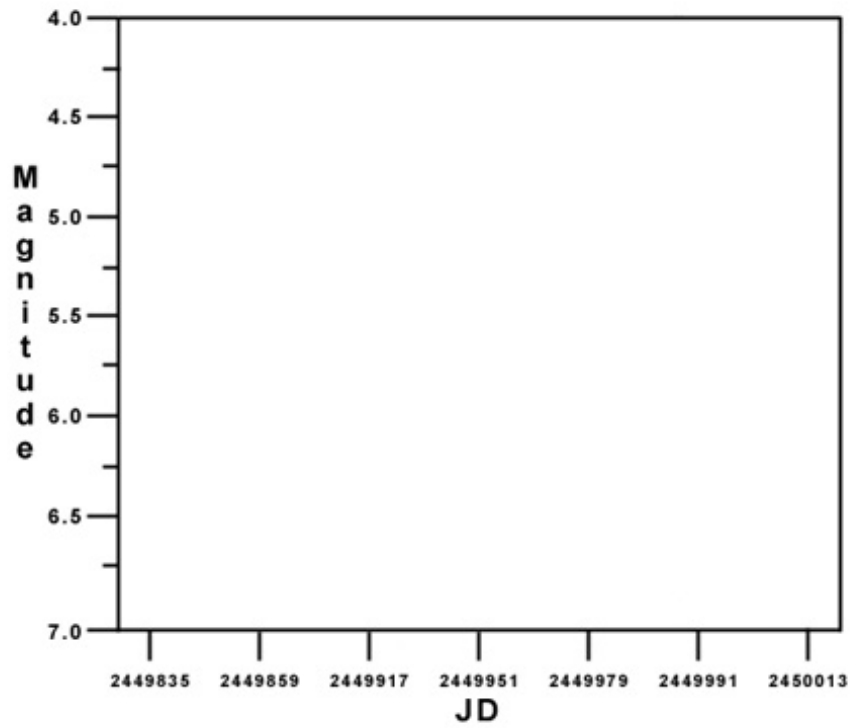
### Variable Stars in Cygnus: Estimating Magnitudes

The W Cyg Field Slide #1 is the first of a series of 7 slides taken of the variable star over a period of approximately 150 days. The set covers nearly the entire range from maximum magnitude (brightest) to minimum magnitude (dimpest.) You will note as you move through the slides that W Cyg does not appear in exactly the same spot in each of the slides. This is because it is difficult for a photographer to set up in the exact same spot when photographing the sky several days apart. The slides also appear in different hues and sometimes with fewer stars in the field. This is the result of different atmospheric conditions on the dates that Cygnus and W Cyg were photographed.

A finder slide with W Cyg and the comparison stars circled has been provided below. Use it to locate W Cyg and the magnitudes of the comparison stars in the sequence of images beneath it.

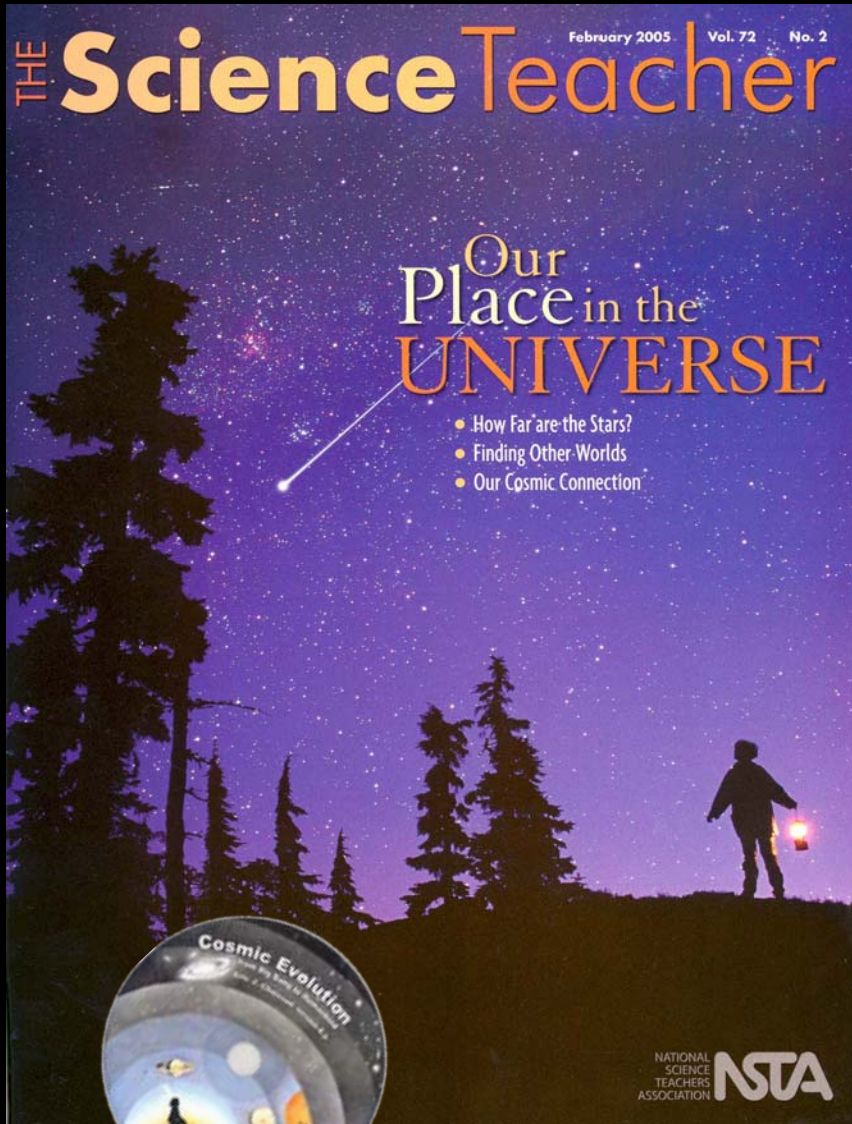


JD 2449835





# Stellar Evolution - A Journey with Chandra



Chandra :: Educational Materials :: Stellar Evolution :: Our Cosmic Connections Activity - Netscape

File Edit View Go Bookmarks Tools Window Help

http://chandra.harvard.edu/edu/formal/stellar\_ev/cosmic/

Chandra :: Educational Materials :: Stellar ...

ABOUT CHANDRA | EDUCATION | FIELD GUIDE | PHOTO ALBUM | PRESS ROOM | RESOURCES

### EDUCATIONAL MATERIALS

#### Our Cosmic Connections Activity

**CLASS ACTIVITIES**  
**BACKGROUND**  
 GALACTIC NAVIGATION  
 CHANDRA 101  
 TRACKING CHANDRA  
 ASK AN EXPERT  
**INTERACTIVE GAMES**  
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**EDUCATION LINKS**

Search  Go

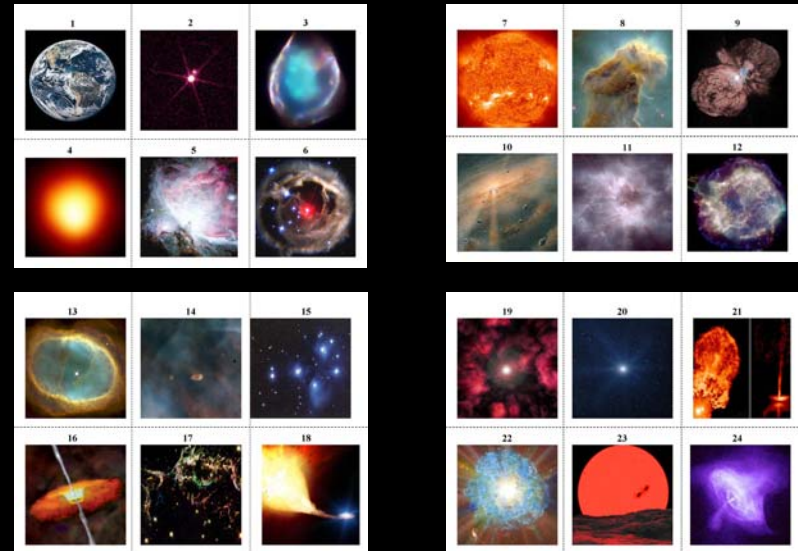
**WEB SITE TOOLS**  
 CHRONICLES  
 EMAIL NEWSLETTER  
 SITE MAP  
 NEW & NOTWORTHY  
 IMAGE USE POLICY  
 QUESTIONS & ANSWERS  
 GLOSSARY OF TERMS  
 DOWNLOAD GUIDE

**CHANDRA**  
X-RAY OBSERVATORY

**Lola Chaisson, Artist**

Ever since the first stirrings of consciousness, humankind has lifted its eyes towards the mystery of the heavens and found solace in the contemplation of the seemingly peaceful and eternal panorama of the night sky. People of ancient cultures viewed the sky as the inaccessible home of the gods. They observed the daily motion of the stars, and grouped them into patterns and images. They assigned stories to the stars, relating to themselves and their gods. They believed that human events and cycles were part of larger cosmic events and cycles. The night sky was part of that cycle. The steady progression of star patterns across the sky was related to the ebb and flow of the seasons, the cyclical migration of herds and the hibernation of bears, the correct times to plant or harvest crops. Everywhere on Earth people watched and recorded this orderly procession with symbols carved into bones and antlers, paintings on elk hide and rocks, and stone monuments and alignments. The motions of the Sun, Moon, stars and planets served as their calendar, clock, and compass.

We still have not lost our fascination for the night sky. The colored and twinkling display overhead causes us to pause and reflect, invoking the same deep stirrings that our ancestors felt when they looked towards the stars. When we look up we feel connected to the grandeur of the sparkling array above us; however we no longer view the sky as inaccessible. Technological advances are taking us on






# Stellar Evolution - A Journey with Chandra


Chandra X-ray Observatory :: Interactive Webquest - Netscape

## Interactive Cosmic Webquest



A	B	C	D	E
F	G	H	I	J
K	L	M	N	O

- A Type Ia supernova
- A mid-sized star
- A massive star



#1

- > Introduction
- > Directions
- > Print
- > Reset

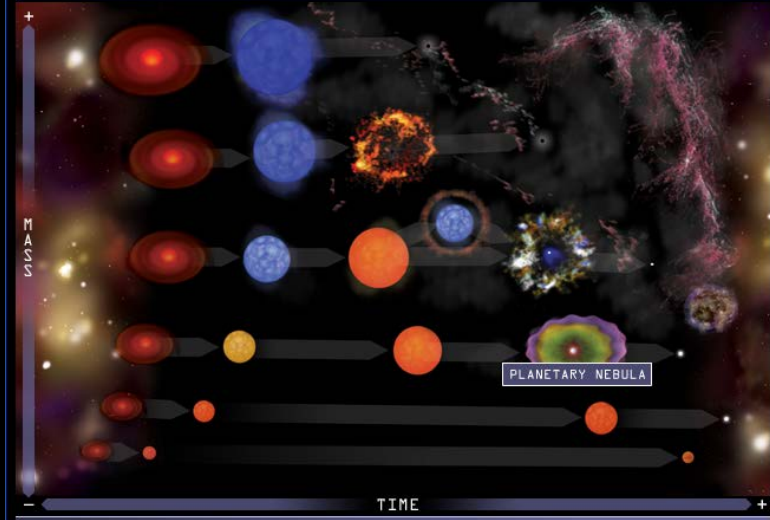
A		I	
B		J	
C		K	
D		L	
E		M	
F		N	
G		O	
H			

CHANDRA X-RAY OBSERVATORY

Stellar Evolution Activity - Mozilla Firefox

## STELLAR EVOLUTION

HELP PRINT PDF BACK CLOSE



PLANETARY NEBULA

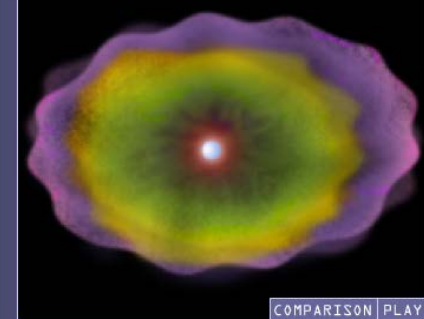
Stellar Evolution Activity - Mozilla Firefox

## STELLAR EVOLUTION

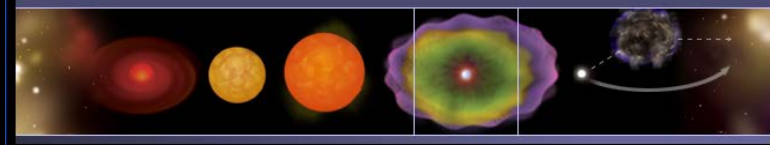
HELP HOME BACK NEXT CLOSE

### Planetary Nebula

After the core-helium-burning giant phase, all of a Sun-like star's available energy resources will be used up. The exhausted giant star will puff off its outer layer leaving behind a smaller, hot star with a surface temperature of about 50,000 degrees Celsius. When the high speed "stellar wind" from the hot star rams into the slowly moving material ejected earlier, the collision creates a complex and graceful filamentary shell called a planetary nebula. A composite image of the **Cat's Eye Nebula** (see comparison) from Chandra (purple) and Hubble (red & green) shows where the hot, X-ray emitting gas appears in relation to the cooler material seen in optical wavelengths.

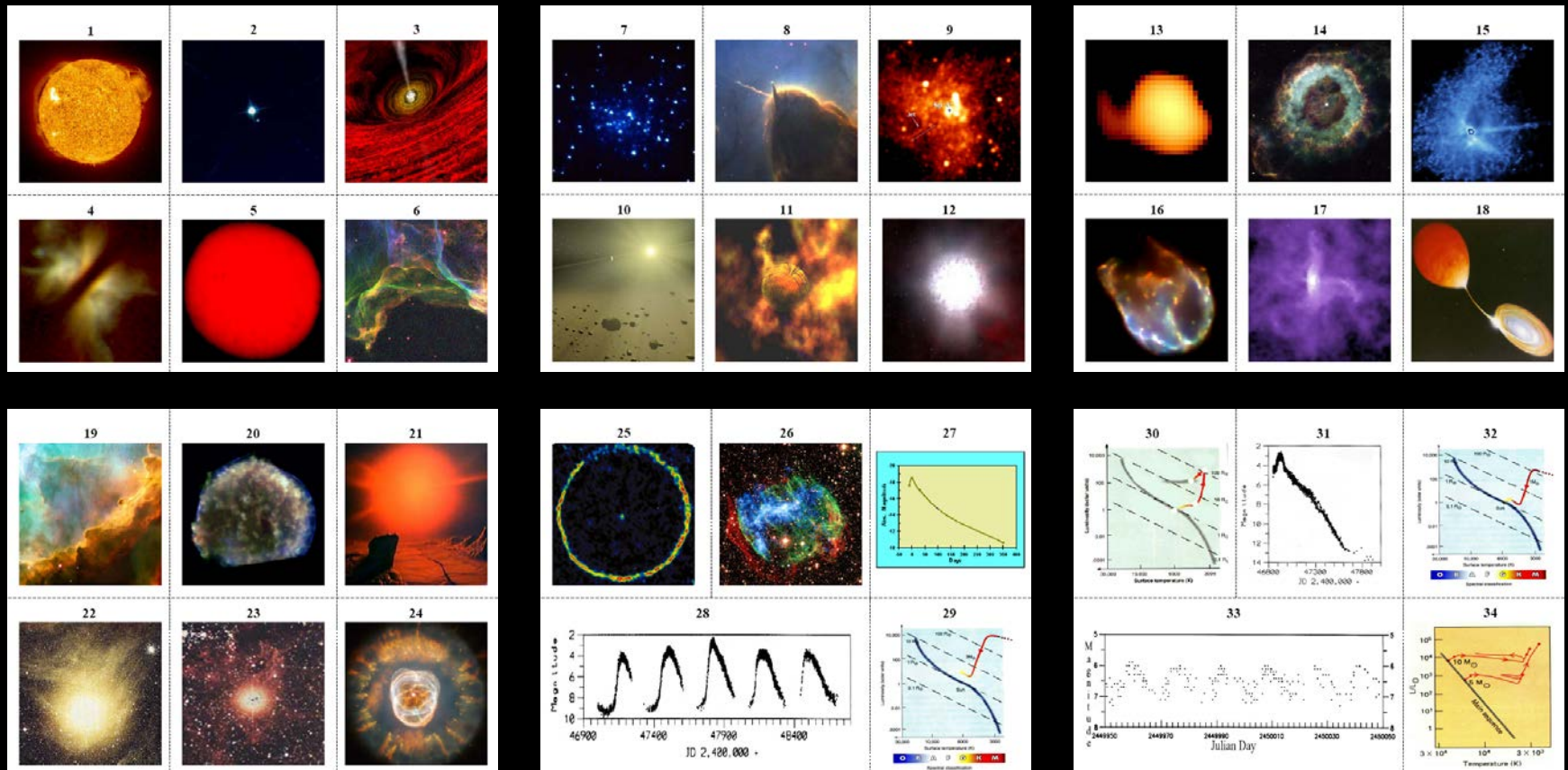


COMPARISON PLAY



# Stellar Cycles Sets and Cosmic Connections Request URL: [http://chandra.harvard.edu/edu/epo/request\\_special.html](http://chandra.harvard.edu/edu/epo/request_special.html)

## Stellar Cycles Card Set:





# Additional Resources:

Wright Center for Science Education at Tufts University - Netscape

http://www.tufts.edu/as/wright\_center/

Wright Center for Science Education Tufts University

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- General Info
- Fellowships
- Partnerships
- SciVisLab
- Workshops
- Conferences
- Lectures
- Posters

**FEATURES**

- For Teachers
- Moon Phase

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**Workshops** Summer 2004 free teacher workshops

The Wright Center is dedicated to the creation and sharing of novel instructional techniques and interdisciplinary resources for pre-college teachers. Through its fellowships, workshops, seminars, and a variety of public-outreach activities, the Center provides leadership in the training and retraining of science teachers to use innovative methods to stimulate young minds.

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**STARFINDER** Hubble Space Telescope video series now available online. View the skies through this window on the universe.

**New Book** *The 13th Labor: Improving Science Education*. Get informed on current science education strategies.

**Cosmic Evolution Web Site** View the past, present and future of the Universe as you move along the Arrow of Time.

**Past Teacher Workshop presentations and web resource materials available here online.**

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Wright Center for Science Education at Tufts University - Netscape

http://www.tufts.edu/as/wright\_center/fellows/sci\_olympiad/sci\_olympiad.html

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**FAST FIND**

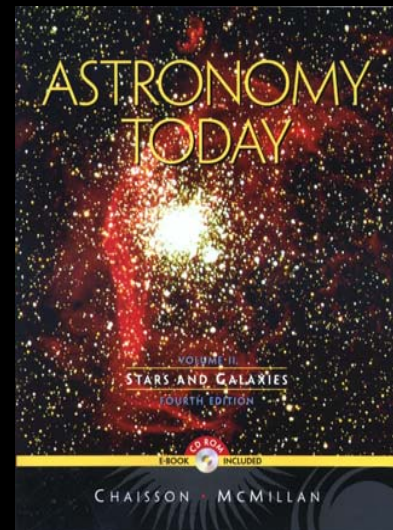
- General Info
- Fellowships
- Partnerships
- SciVisLab
- Workshops
- Conferences
- Lectures
- Posters

**FEATURES**

- For Teachers
- Moon Phase

**Science Olympiad**

- Science Olympiad Coaches Clinic
  - 2002 Astronomy C Presentation w/o audio (requires free WinZip and PowerPoint Viewer)
  - 2003 Astronomy C Presentation with audio (requires free WinZip and PowerPoint Viewer)
  - Preparation Guidelines for Astronomy C
  - Introduction to Experimental Design
  - Cell Biology Process 1
  - Cell Biology Process 2
  - Cell Biology Process Skills
  - Designer Genes Guide
  - Forestry Training Guide
  - Forestry Tree List by Family
  - Forestry Sample Tournament
  - Process Skills for Life Science
  - Reach for the Stars Tips
  - Science of Fitness - B Division
  - Science of Fitness - C Division
- Astronomy (2004 Juniata College National Competition - B Division - Reach for the Stars)
  - Question and Response Sheet
  - Answer Key
- Astronomy (2004 Juniata College National Competition - C Division - Reach for the Stars)
  - Instructions and Questions
  - Student Image Set A
  - Student Image Set B
  - Answer Sheet
  - Answer Key
- Astronomy (2004 Pennsylvania State - B Division - Reach for the Stars)



# The American Association of Variable Star Observers

AAVSO: Types of Variable Stars - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://www.aavso.org/vstar/types.shtml

AAVSO HOME > variable stars > types

## Variable Stars

### Types of Variable Stars

**Variable Stars**  
Variable Star of the Season  
Powerpoint Intro  
Stars Easy-To-Observe  
Historical Light Curves  
Naming  
Harvard Designation  
Types  
Further Reading  
Research: AAVSO in Print  
Observing Manual


**Main sections of web**  
The AAVSO  
**Variable Stars**  
Observing  
Access Data  
Publications  
Online Store  
Education: HOA



Variable Stars are stars that vary in their light output. The origins of these light variations define the classification system of variable stars.

There are two kinds of variable stars; **intrinsic** in which variation is due to physical changes in the star or stellar system and **extrinsic** in which variability is due to the eclipse of one star by another or the effects of stellar rotation.

There are four main classes of variable stars. Within the *intrinsic* group of variables there are two classes: **pulsating** and **eruptive**. Within the *extrinsic* group there are two classes: **eclipsing binary** and **rotating** stars. Below is a more thorough investigation of these four classes of variable stars.

### Pulsating Variables

 Pulsating Variables are stars that show periodic expansion and contraction of their surface layers. Pulsations may be radial or non-radial. A radially pulsating star remains spherical in shape, while a star experiencing non-radial pulsations



Impression of a Cataclysmic Variable with an Accretion Disk  
Image by Mark A. Gattick  
(<http://space-art.co.uk>)

<http://www.soinc.org/store/TG-DVD-06v10.htm>



**NEWLY UPDATED COACHES MANUAL  
(AVAILABLE ONLINE AT THE NSO WEBSITE)**